THE HYGIENE

OF

TRANSMISSIBLE DISEASES:

Their Causation, Modes of Dissemination, and Methods of Prevention.

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PREFACE.

THE contents of this book are essentially the subject-matter of a portion of my lectures on General Hygiene at the University of Pennsylvania.

It is not the purpose of this work to present the subject of Hygiene in the comprehensive sense ordinarily implied by the word, but rather to deal directly with but a section, certainly not the least important, of the subject—viz., that embracing a knowledge of the preventable specific diseases. Incidentally, as occasion may require, there are discussed those numerous and various factors that have not only a direct bearing upon the incidence and suppression of such diseases, but that are of general sanitary importance as well.

In the preparation of this work only the most trustworthy authors have been consulted, and only those precepts embodied that are now generally accepted by sanitarians as sound.

It will be manifest to the reader that a great deal is still wanting to complete our knowledge upon many important phases of the subject, and no effort has been made to disguise this fact.

The frequency with which requests are received for information concerning the detailed management of transmissible diseases is in part the reason for the publication of this book.

I trust the work may serve a useful purpose.

A. C. A.

CONTENTS.

THE HYGIENE

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INTRODUCTION.

HYGIENE is the science that deals with the laws of health, in the broadest sense.

Practical hygiene, or sanitary science, is the *art* of preserving health (or of preventing disease), and includes a consideration of the methods that are employed in investigating the manifold phases of the subject.

It is obvious that the fundamental points to be considered in the study of hygiene are those bearing upon the conditions under which we live. Hygiene is not so much a study of man as a study of man's surroundings, with the view of determining in how far these are conducive or detrimental to his well-being.

Among the earliest medical and ecclesiastical writings are encountered laws for the sanitary guidance of man. It is due largely to the inculcation of these precepts, handed down from generation to generation, that we follow particular modes of living and still instinctively avoid certain conditions then thought to be harmful. Probably the most familiar of the early writings on the subject are the laws of Moses for the guidance of his people. Since practically nothing was then known as to the direct causation of disease, these laws were of necessity empirical, though the measures recommended for preventing the spread of contagion, for cleanliness, for the killing of animals for food, for the isolation of infectious maladies, and for the renovation of dwell-

ings inhabited by contagious diseases are alone sufficient to warrant the belief that they were formulated from close observation and trustworthy experience.

The older writings on hygiene, and in fact many of those of comparatively modern date, were in the main speculative, representing the dictates of instinct and intuition. They were, nevertheless, of undoubted benefit to those who heeded them and, in so far at least as the Jews are concerned, were unquestionably instruments in repeatedly shielding them from the ravages of pestilence.

That the importance of personal and municipal hygiene was fully appreciated by the earlier civilizations generally, there is abundant evidence. The question of public health was one of vital importance, and their desire and ability to carry their precepts into practice have been abundantly discovered through the researches of the archeologist. In many instances their devices for baths, water-supplies, disposal of sewage, and for light and air left little to be desired.

With the progress of time, the growth of communities, and the demands of modern life, it became evident that the earlier sanitary codes must be recast to meet the requirements of newer conditions. The older regulations were based, as has been said, in many important particulars, upon speculation and erroneous conceptions; though it must be admitted that they erred more frequently on the right than on the wrong side.

About the middle of the present century it was realized by those who have done most to place hygiene on a sound basis that, through the application of methods of precision to the study of man and his surroundings, much light could be thrown upon many phases of the problem that had hitherto been but imperfectly understood. In consequence, through the utilization of chemical, physical, histological, statistical, and bacteriological methods, the empirical hygiene of the past has in part given place to the more exact hygiene of to-day. In the light shed by such trustworthy methods of analysis we are in a favorable position to interpret and appreciate the meaning, the value, and the wisdom of many of the

laws and customs that were in vogue in earlier times for the regulation of health and disease.

The foundation of modern hygiene is laid in the scientific investigations of von Pettenkofer on ventilation and heating, on the relation of soil-moisture to health, on the physical properties of clothing; and in those of himself, associated with Voit, on the chemistry of respiration and general nutrition, and the chemico-physiological values of food-stuffs in the process of alimentation; and in the brilliant, epoch-making researches of Koch upon the etiological relation of micro-organisms to disease. With the impulse given to the work by the intelligent deductions of these pioneers in modern hygiene there was a development in our knowledge along all the manifold ramifications of the subject, and to-day the field of hygiene has assumed such vast proportions that only a rare intellect can master in detail its numerous phases. Indeed the subject is already divided into its specialties, and complete works on hygiene are no longer attempted by single individuals, but are rather edited as systems of monographs, each contributed by individuals who devote their time exclusively to the study of this or that particular branch of the subject, and who, therefore, have the special knowledge necessary to clear and complete enunciation. Not only has the development of knowledge upon hygiene alone been very conspicuous but, through special investigations of hygienic significance, its influence has been widespread, and much light has been thrown upon topics of general medical interest.

It is manifestly inadmissible longer to connect the teaching of hygiene with that of any other branch of medicine. It has become a science of itself, and as such should be in the hands of those who have undergone the special discipline necessary to appreciate fully the nature and importance of the problems involved. The time is past for the student to receive adequate instruction in this work from the "Professor of Obstetrics and Hygiene," of "Dermatology and Hygiene," of "Materia Medica and Hygiene," as has been the case for so long a time in many institutions of learning.

The times demand that the teacher of this department of work be one who has been systematically trained in its various departments, not of necessity to the extent of being master of each, but certainly as master of some, and in general to a degree that will enable him to comprehend and elucidate fully the problems that present.

Why should a physician trained to cure the sick equip himself with a knowledge that he is to employ in preventing sickness? Why should a physician practise preventive medicine and follow the precepts of hygienic teaching? are questions that are occasionally asked. One might as readily ask, why does one experience the impulse to rescue from danger a stranger, in whom he has no direct interest? Laying aside the question concerning his functions as a physician, there is every moral reason why he as a man should use his best endeavors to lessen suffering and save life, in so far as it lies in his power to do so, and this too regardless of whether it is to be of direct profit to him or not.

In the second place, there are material reasons for a physician's having a fairly accurate knowledge of the advances in preventive medicine. His patients demand it. With the universal progress in general education the public is no longer satisfied that a physician enter the house, prescribe his medicines, and depart; they desire more: they wish to know the nature, the origin, and the cause of the sickness, the most likely channel or channels through which the disease was contracted, and the most reliable means of preventing its recurrence or spread. If the doctor cannot promptly supply reasonable answers to these questions, he need not be surprised if his employment be given to someone else who can.

In the third place, for his own enlightenment and personal welfare the physician should be familiar with sanitary laws, especially those concerning the causation and spread of disease and the means of prevention. He should be familiar with the modes of infection, the methods of disinfection, the means for the isolation of the sick, and the general rules of prophylaxis in the management of contagious diseases. He should be familiar with the channels through which he him-

self may become infected, or the means by which he may serve as a carrier of infection and the proper precautions for preventing such accidents. As an educated physician he should know, and as a conscientious physician he should practise these precepts for the good, not only of his own patients, but of the community of which he forms a part. The medicine of the period tends more and more in the direction of prevention, and if the physician proposes to keep himself abreast of the times it is imperative that he be in touch with the advances along these lines. While ignoring the subject a new medicine grows up about him, and he is suddenly aware of his presence in an atmosphere unfamiliar and wholly uncongenial—an atmosphere that he does not appreciate, and with which he experiences no intelligent sympathy.

From time to time the teachings of hygiene are assailed by hostile attacks, and proof is demanded that the practice of sanitary precepts has resulted in the betterment of the conditions under which mankind lives, in the prevention of disease, or in the saving of life. While it cannot truthfully be said that every so-called sanitary precaution is beneficial or necessary, or that every article in the sanitary code is based on that which is proved to be sound, we can nevertheless combat adverse criticism with an array of evidence that should convince the most sceptical as to the importance, yea, the profound necessity, of an intelligent sanitary control of the conditions under which we live. For instance, to cite a few of the triumphs of hygiene: Until the beginning of the present century the average mortality from small-pox in Prussia was 3 per 1000 of population. In times of epidemics this ratio was commonly very much increased. Since the introduction of compulsory vaccination the mortality from this disease has fallen to its present figure of 0.03 per 1000 of population, and, as Flügge states, cases of small-pox are now looked upon in many provinces of Prussia as medical curiosities.

During the seventeenth and eighteenth centuries the annual death-rate from this disease in London ranged from 2 to 4 per 1000 of population; with the introduction of general vaccination it had fallen for the interval between 1883 and

1892 to 0.073 per 1000. Schulz states that by the calculations of the Imperial Health Bureau at Berlin, based upon the statistics of mortality for small-pox for the periods between 1845 and 1869, and 1875 and 1885, at least 74,000 lives have been saved through vaccination in Prussia alone.

Reductions in the mortality from this disease analogous to those just cited have occurred in all countries where vaccination has become general.

During the seventeenth and eighteenth centuries a very large proportion of sickness and death in the navies and in the merchant service was due to scurvy, and no inconsiderable number in public institutions, hospitals, jails, reformatories, workhouses, etc., were from the same cause. By virtue of proper attention to diet, cleanliness, and habitation, scurvy has practically disappeared from among civilized peoples.

Typhus fever, also so frequent in former times among the inmates of overcrowded hospitals and other public institutions, has, under modern sanitary conditions, become a rarity.

By attention to the drainage of soils and the introduction of pure water for domestic purposes, it has been demonstrated that cholera and typhoid fever can be almost eliminated. No more striking instance of this can be cited than the remarkable reduction in the typhoid death-rate in the city of Munich. In 1856 the mortality from typhoid in Munich was 2.91 per 1000 of population. At that time the soil of the city was honeycombed with cesspools, and a large part of the water-supply of the city was obtained from wells and pumps sunk in this soil. Between 1856 and 1887 the condition of the city underwent, at several conspicuous periods, a radical sanitary reform. The cesspools were filled, and the introduction of new ones was prohibited. An elaborate system of sewers was introduced, pumps and wells were abandoned, and a pure water-supply was brought from a source beyond suspicion of pollution. As a result of all this, the mortality from typhoid fever fell, and in 1887 it had reached the very low ratio of 0.1 per 1000 of population, a reduction of about 96.6 per cent. in the deaths from this disease alone.

Within less than one year after the adoption of approved methods for the purification of the water-supply of Lawrence, Mass., the death-rate from typhoid fever was reduced nearly 59 per cent., and in Chicago the deaths from this disease were diminished approximately 60 per cent. within a year after the domestic water-supply was obtained from a non-polluted source.

As a result of the proper drainage of soils, a diminution in the frequency of pulmonary, intestinal, and malarial troubles has everywhere been observed.

These few illustrations, not to mention the advantages that have accrued from increased attention to personal hygiene, to diet and raiment, to the laws of disinfection, isolation, and quarantine, should serve as convincing proof that the efforts of the hygienist have not been in vain; that they have not only been of enormous benefit to mankind, but that with the increased store of knowledge that is constantly accumulating, they are still further capable of such benefits. Already countless lives have been saved; we are told that the longevity of the human race has been increased, and in every way the conditions under which man lives are better than they were a few years back.

In citing, as illustrations, the advances that have been made along the lines of hygiene and the good that has been derived from them, it is not our desire to leave the impression that the millennium has arrived; that our stock of knowledge on the subject is complete or satisfactory in all details; or indeed even that the knowledge we possess is utilized to the extent that its importance demands. When we realize that the majority of all deaths is still from preventible causes, most of which are already quite familiar to us, it is manifest that this must be in a large measure due to an indifference on our part to put into practice even that knowledge which we already possess for their prevention. The great majority of deaths result from infection, from insufficient attention to diet, and from want of care with regard to the temperature of the body—that is to say, they are the direct outcome of our surrounding circumstances. We consider it quite within the

bounds of moderation and discretion to declare that, by the indefatigable practice of the sanitary precepts now known to be sound with regard to the prophylaxis and management of the commoner infectious diseases, to the hygiene of infancy, to diet and clothing, the death-rate from preventible causes could be conspicuously reduced, and this, too, without the addition of a single new fact to the knowledge that we already possess.

SECTION I.

THE CAUSATION OF DISEASE.

As has been stated, the object of hygiene is to prevent disease. It is therefore necessary to an understanding of the means employed in securing this end that we possess a clear comprehension of the factors concerned in the causation and dissemination of disease.

The causative factors in disease are manifold; they differ in nature the one from the other, and are of varying degrees of importance in their relation to morbid conditions.

In considering this phase of our studies it is well to bear in mind from the beginning that beyond traumatisms and direct poisons there is probably no single, absolute cause of disease, but that the abnormal state we call disease represents the termination of a chain of circumstances the various links of which, while having more or less of a direct bearing upon the others, are of different degrees of importance to the process. Thus, by way of illustration, we say that tuberculosis is caused by a specific micro-organism, and no one doubts this; but at the same time there is no one who believes for an instant that, if to a number of individuals in sound health this micro-organism gains access, tuberculosis will with certainty result in all cases. There are other factors that come into play and must be taken into consideration. On the one hand, there are circumstances that modify the disease-producing powers of the micro-organism, so that at one time it may be comparatively feeble as regards this property, while at another it is infective to the fullest extent. On the other hand, there are modifying influences constantly at work upon the individual, some of them placing him in a condition to survive exposure to the most virulent forms of infection, while others

so modify the normal vital resistance with which nature has provided him that he readily falls a prey to what would otherwise be a comparatively insignificant foe. In other words, certain influences to which man is exposed during the course of his existence *predispose* him to disease in general, while others are concerned in directly *exciting* certain definite groups of symptoms and pathological manifestations, which are usually classed as specific diseases. In considering the causation of definite or specific diseases it is impossible to ignore those surrounding conditions that predispose to them. Reverting to our illustration, the *exciting* or direct cause of tuberculosis, with all its varied expressions, is *Bacillus tuberculosis*, while the *predisposing* or indirect causes may be numerous—as age, race, occupation, unsanitary surroundings, and heredity.

In their relation to specific disease-processes in general, the causative factors are therefore usually classed as Exciting or Direct and Predisposing or Indirect.

Predisposing Causes of Disease.—By this term is meant those conditions with which man is surrounded that have a tendency to so reduce his normal vital powers that he is no longer capable of resisting the inroads of the direct, exciting causes of disease. The term "vital" or "animal resistance" was at one time vaguely employed in explanation of the efforts of the tissues to evade infection. In the light shed by modern investigation upon the means of defence possessed by the animal organism for the resistance of disease, vital resistance signifies a group of animal functions, some of which are capable of ready demonstration, that is possessed by every living being in health, and through the exercise of which the body is enabled to withstand, within limits, the influence of detrimental agencies.

We now know that the circulating fluids, certain wandering cells, and certain fixed cells of the animal economy are directly antagonistic to many of those particulate causes of disease known as micro-organisms; that through the exercise of these vital functions invading bacteria are often destroyed before sufficient time has elapsed for them to multiply and evolve their products which are instrumental in disturbance

of function and destruction of tissues. We have reason for believing, moreover, that within these same fluids and cells lies also the power of neutralizing to a certain extent the poisonous products of bacteria which themselves may not be destroyed by the body.

The highest expression of this vital phenomenon is naturally found in the healthy being. Agencies that tend to reduce the general health, such as exposure, fatigue, malnutrition, debauch, etc., tend likewise to diminish the vital resistance, and in this manner render the individual more susceptible to disease.

Age.—As a factor in predisposing to disease, the influence of age cannot be ignored. To certain maladies the young are more prone than the old, while to others the reverse is the case. The greatest number of deaths, and hence the greatest amount of sickness, occurs among the very young and the very old—*i. e.*, before the age of five and after the age of sixty-five to seventy years, indicating that at these periods the vital processes are at the one time but imperfectly developed, while at the other they are declining in efficiency. There are certain diseases common to all ages, though their pathological manifestations may vary according to the age of the subject affected. For example, tuberculosis is seen in the infant, the adult, and the aged; but in childhood its expressions are most frequent in the lymphatic, the osseous, and the serous tissues, while in maturity and old age the lungs are usually involved when tuberculosis is anywhere present in the body (Louis's law).

In general, it may be said that during infancy and childhood the diseases most frequently encountered are those connected with the development of anatomical structures and the establishment of physiological functions. To this may be added those dependent upon congenital defects and upon special hereditary tendencies, those consequent upon the neglect of careless and inexperienced mothers, those resulting from undue exertion, as of occupation, during and after pregnancy, those that occur in consequence of improper food and clothing, and lack of cleanliness and pure air. Certain

of the acute exanthemata, as measles, scarlatina, rötheln, varicella, etc., are much more frequent in childhood and early youth than later; while others, as erysipelas, variola, and typhus fever, may appear at any period of life. Typhoid fever is most frequent in youth and early adult life. Its greatest frequency is seen between the ages of fifteen and twenty-five years. After forty-five years it is comparatively rare.

The frequency of the acute exanthemata in childhood is probably accountable for their comparative infrequency in adult life, for we have reason to believe that a single non-fatal attack of either or all of these maladies in childhood affords a more or less permanent protection—immunity—to that child from subsequent attacks of the same disease at a later period of its life.

Adult life is not conspicuously more prone to one than to another group of diseases. At this period man's physiological processes are developed and in active operation, and his freedom from or affliction with disease will depend very largely upon the conditions under which he lives. If circumstances permit him to lead a rational life, giving due attention to exercise, diet, clothing, cleanliness, and hygienic surroundings, there is no reason why he should not be comparatively safe from disease. If, on the other hand, his life is passed under conditions of extreme poverty, overcrowding, intemperance, exposure to excesses of heat, cold, or moisture, foul air, bad food, impure water, uncleanliness, and exposure to contagion, there are equally good reasons for expecting him to fall a ready prey to disease, for these are the underlying causes of the vast majority of sickness and death among all ages in great cities.

The diseases incidental to old age, a period difficult to define accurately because of the variation in the time of its onset in different individuals, are those that depend upon the gradual loss of power on the part of the organs to perform their normal physiological functions, with the consequent disturbance of nutrition and the multiform abnormal manifestations that this defect entails. In short, the diseases of age

are mainly degenerative in their nature, and simply indicate irregularities that are incidental to the progressive wearing out of the machinery of life. Among the commoner may be mentioned those affecting the heart and arteries, those of the renal and hepatic systems, catarrhal conditions of the mucous membranes, diseases consequent upon intemperance, rheumatic and gouty affections, cancers, and tumors.

Sex.—With regard to certain diseases that depend upon the existence of particular anatomical structures, it is obvious that sex is an important predisposing factor, particularly in connection with those maladies that affect the organs by which the sexes are differentiated.

The influence of sex does not, however, cease here. With regard to other diseases, and indeed to disease in general, it has a manifestly important bearing. For some reason or reasons, for there are probably many to explain it, the general death-rate among females is uniformly lower than that among males, and statisticians, as a rule, assign to women a greater expectation of life than to men. On reflection we might be prepared for this, for by the nature of things males are brought, during the course of their daily life, into closer contact with a greater variety of surrounding conditions that may influence their health than are women. Man's exposure to accident is also much greater.

With regard to certain diseases, the influence of sex is very apparent, and in some cases this influence varies conspicuously according to age. In some instances the influence of sex does not appear until the advent or after the age of puberty. Before this period the sexes are less markedly differentiated in their relation to disease. By way of illustration :—This influence of age and sex upon mortality is very strikingly brought out in connection with cancer, anemia, and typhoid fever. For the six years ending with May 31, 1890, according to the last (eleventh) United States Census, there occurred in New York City among the white population 48 deaths from cancer in individuals under fifteen years of age; of these 24 were in males and 24 in females; for the ages between fifteen and forty years there were 782 deaths from

the same cause; of these 222 were in males and 560 in females; while for all over forty years of age the number of deaths from cancer was 3952, of which 1299 occurred in males and 2653 in females.

Anemia resulted fatally in 49 individuals under fifteen years of age; of these 22 were males and 27 females; it caused the death of 64 persons between the ages of fifteen and forty years; of these 18 were males and 46 females; while for the ages over forty years there were 56 deaths, of which 19 were males and 37 females.

The deaths from typhoid fever among those under fifteen years of age were 290, of which 152 were males and 138 were females; among the deaths of those between fifteen and forty years of age from the same cause, there were 828 males and 526 females, while the deaths of those over forty years were found to be 213 males and 148 females. In the case of cancer it is clear that advancing years and female sex offer conditions favorable to its development. In the case of anemia there seems to be no preference for the sexes before puberty. After that time until the period of old age females are much more liable than males. With typhoid fever we find the greatest number of deaths during the period of youth and early adult life, but the greater number of deaths is among males[1] (see Table I.).

TABLE I.—*Deaths among the white population of New York City from Anemia, Typhoid Fever, and Cancer during the six years ending May 31, 1890, with distinction of age and sex.*

	Anemia.		Typhoid Fever.		Cancer.	
	Males.	Females.	Males.	Females.	Males.	Females.
Under 15 years	22	27	152	138	24	24
From 15 to 40 years	18	46	828	526	222	560
Over 40 years	19	37	213	148	1299	2653
Totals	59	110	1193	812	1545	3237

[1] The numerical method here employed may not be acceptable in the light of accurate statistical methods. The figures represent only the absolute numbers and not the relation of such numbers to a fixed standard of comparison. They are, however, quite near enough to accuracy to serve as a fair illustration.

According to the same document, males afford a greater number of deaths than females from typhoid fever, venereal diseases, alcoholism, lead- and other forms of poisoning, hydrocephalus, tetanus, and trismus nascentium, convulsions, diseases of the brain and cord, angina pectoris, aneurysm, laryngitis, diseases of the liver, urinary calculus and renal diseases, diseases of the bladder and genito-urinary tract, diseases of the bones, of the spleen, and accidents. Females succumb more frequently than males to malaria, cancer, anemia, dropsy, ascites, diseases of the stomach, peritonitis, and, of course, to diseases of the female reproductive organs, and to those incidental to pregnancy and childbirth. In some instances the reason for these differences is manifest; in others it is in obscurity.

Race.—It is a well-known fact that the predispositions of the different races of mankind to particular forms of disease are not uniform. Some exhibit a peculiar susceptibility to certain maladies, while others possess a comparative degree of immunity from them.

In some instances this is explainable through the prolonged exposure of races to particular diseases, resulting in their acquisition of a greater degree of tolerance to them than is seen to be possessed by other races, or other portions of the same race, that have not been similarly exposed.

It is difficult to obtain trustworthy data that are of general application in deciding the influence of race upon disease, because of the many determining factors that come into play. Nevertheless, through vital statistical studies of groups of people of different races living under various conditions, we have obtained data of more or less importance that are indicative of the relative frequency of different diseases among them. Whether the results obtained by this method are entirely trustworthy or not it is difficult as yet to decide; the differences, as said, may depend upon so many surrounding circumstances—the social conditions, with all that these entail, under which the different peoples were living at the time of the observation being perhaps the most important.

With regard to the influence of race on disease in general,

there is more or less disagreement of opinion, though in several special instances there is striking evidence in favor of such a relation. There is a general consensus of opinion that the negro is less susceptible to yellow fever and malaria than the white man, and the white man less susceptible to pulmonary troubles and cholera than the black man; that the German oftener falls a prey to cancer than his Celtic cousin; and that the Jew escapes more frequently from diseases of a tuberculous nature and from epidemic diseases than does any other race of mankind. But when we attempt to carry the investigation further confusing factors, varying in the degree of their importance, are encountered, and the results obtained cannot be considered as entirely reliable for purposes of generalization. It is probable that there is no disease to which mankind is liable from which any race of man possesses absolute natural (*i. e.*, congenital) immunity.

For the study of race-influence upon the frequency of and mortality from special diseases among different peoples, living under approximately similar conditions and equal degrees of exposure to disease, the United States with their large population, consisting of representatives of almost every nation, the diversity of their geological and climatic conditions, and especially, as in the great cities, the more or less intimate admixture of the different races, offer an unusual opportunity.

Important light is shed upon this matter through the Census and Vital Statistics of our people, taken every ten years. In the compilation of these reports it is customary to compare the death-rates, or actual deaths (fair indices of sickness) from different causes among the foreign population, with the deaths among the native white and colored population, and while the deductions drawn from this method are of undoubted value in illustrating the relative susceptibilities of these various peoples to different diseases, it must be remembered that the comparisons are made between peoples of very different social conditions, and that they are not therefore as trustworthy as they would be were the inequality in this respect less; though they undoubtedly indicate the frequency of disease under the existing circumstances.

The census of 1890 for the city of New York shows the lowest death-rate from all causes to have been among the Russians and Poles, the majority of whom in this country are of the Semitic race, while the highest general death-rate was among the Italians. The fallacy and inconstancy of the results obtained by this method are best illustrated by the results of statistics compiled along the same lines and at the same time in Boston and Philadelphia. In Boston the highest death-rate from all causes and at all ages was among the Irish, and the lowest among the French; while in Philadelphia the native whites experienced the greatest loss from death and the Bohemians the least. The high (relatively speaking) death-rate among the native white population of Philadelphia is probably due to the relatively larger number of married and marriageable native Americans in that city, and consequently a larger number of young children than are found in any of the other groups (Billings).

TABLE II.—*Comparing the death-rates per 1000 of white and negro populations for the six years ending with May 31, 1890 (Eleventh United States Census):*

	White.	Colored.
Boston	23.71	31.92
New York	29.86	33.27
Brooklyn	25.90	30.54
Philadelphia	22.69	31.25
Baltimore	21.98	35.99
District of Columbia	19.75	37.00

A conspicuously constant racial influence upon susceptibility to disease is observed in comparisons between the death-rates among the white and negro populations. In eighteen southern and four northern cities the eleventh census shows that the general death-rate for all ages was in each case greater among the colored than among the white natives (see Table II.). It is not unlikely, however, that this is due to social condition as much as, if not more than, to racial peculiarity.

As has been stated, the negro is less susceptible to yellow fever than the white man, though this not always the case.

Instances are recorded in which the mortality of negroes from this disease, during times of epidemics, was as great as among the white. The comparative immunity of the negro is probably acquired, as it has been observed that negroes who are born and raised in countries and localities where the disease is unknown are practically as susceptible as whites when exposed to the infection. It may or may not be due to acquired tolerance, or "acclimatization," as it is sometimes called, that a similarly relatively low degree of susceptibility of the negro to malaria is observed; of 614 cases of malaria, seen in Baltimore, and described and analyzed by Thayer and Hewetson, 585 occurred in whites, while only 29 were in colored persons. On the other hand, "there is a general consensus of opinion that the negro is especially liable to Asiatic cholera" (Hirsch). According to Walther (quoted from Hirsch), the mortality from cholera in Guadeloupe during the epidemic of 1865 was divided among the following peoples in the following percentages: Chinese, 2.7 per cent.; Hindoos, 3.26 per cent.; whites, 4.31 per cent.; mulattos, 6.32 per cent., and negroes, 9.44 per cent. During the epidemic of 1866 in this country the mortality from cholera among the white troops (U. S. army) was 77, and that among the colored 135 per 1000 (Hirsch). By the vital statistics of New York city, census of 1890, consumption, pneumonia, heart disease, puerperal diseases, and diseases of the urinary apparatus were found to be more fatal among the negro than the native white population; while scarlet fever, diphtheria, croup, diarrheal diseases, measles, whooping cough, diseases of the liver, and diseases of the nervous system were more fatal to the native white than the colored race.

The table given on page 35 (Table III.) presents these relations numerically.

In numerous instances the Chinese have shown a conspicuous immunity from cholera.

One of the most striking examples of specific racial immunity from disease is, as stated, that observed among the Jews. While they are attacked by the general run of diseases as often as, and sometimes more often than, Christians,

yet they are very much less frequently the subjects of tubercular and acute epidemic diseases than any other race of mankind.

TABLE III.—*Proportion of deaths from different diseases per 100,000 of mean population in the city of New York for the six years ending May 31, 1890, with distinction of color and nativity:*

	White (native).	White (foreign).	Colored.
Scarlet fever	79.58	9.89	11.11
Diphtheria	179.46	17.58	31.94
Croup	78.76	8.59	13.19
Diarrheal diseases	383.24	90.25	243.72
Consumption	238.48	483.83	774.21
Pneumonia	280.15	265.27	324.27
Measles	58.34	6.56	15.28
Whooping-cough	54.24	1.69	39.58
Cancer and tumor	54.92	102.61	45.13
Heart disease and dropsy	130.00	194.95	188.17
Childbirth and puerperal diseases	16.87	38.01	23.61
Diseases of the liver	24.05	53.79	12.50
Diseases of the nervous system	308.64	197.06	240.25
Diseases of the urinary organs	147.76	253.86	242.33

Richardson states that "the mortality from cholera among them is so small that the very fact of its occurrence has been disputed. . . . From epidemics the Jews have often escaped, as if they possessed a charmed life." In "The Vital Statistics of the Jews of the United States," compiled by Dr. Billings in 1890, it is seen that, as compared with the population of the entire United States, and with that of the State of Massachusetts, the Jews "suffered a relatively greater loss than their neighbors by deaths from diphtheria, diarrheal diseases, diseases of the nervous system (and especially from diseases of the spinal cord), from diseases of the circulatory system, urinary system, bones and joints, and of the skin; while their mortality has been relatively less from tubercular diseases, including scrofula, tabes, and hydrocephalus, than the other people with whom they are compared."

The following table (Table IV.), abridged from this report, shows the relative difference, as regards consumption, scrofula, and hydrocephalus, numerically:

TABLE IV.—*Giving the male Jewish death-rate from Consumption, Scrofula, and Hydrocephalus per 1000 total deaths from known causes, as compared with the rates similarly calculated for the entire population of the United States in 1880 and for that of Massachusetts in 1888:*

Diseases.	Jews.	All United States, 1880.	All Massachusetts, 1888.
Consumption	36.57	108.79	129.22
Scrofula and tabes . .	1.04	6.74	30.60
Hydrocephalus . . .	3.13	6.43	11.74

This conspicuous immunity of the Jewish race from disease has attracted the attention of statisticians in several countries of the world, with the result of demonstrating this peculiarity to be pretty uniform. Quoting from the researches of de Neufville, at Frankfort: "The average duration of the life of the Jew is forty-eight years and nine months, and of the Christian thirty-six years and eleven months; . . . half the Jews born reach the age of fifty-three years and one month, whilst half the Christians born attain the age of thirty-six years only. A quarter of the Jewish population is found living beyond seventy-one years, but a quarter of the Christian population is found living beyond fifty-nine years and ten months only."[1] As an explanation of this vital advantage on the side of the Jews, Richardson states "the causes are simply summed up in the term 'soberness of life.' The Jew drinks less than his 'even Christian'; he takes, as a rule, better food; he marries earlier; he rears the children he has brought into the world with greater personal care; he tends the aged more thoughtfully; he takes better care of his poor, and he takes better care of himself." To this might perhaps be added, he has inherited traces of the respect shown by his ancestors for the laws of Moses for the hygienic guidance of the children of Israel.

It would be vain to contend that the observations made under this heading and the statistics presented justify dog-

[1] de Neufville: Lebensdauer und Todesursachen zwei und zwanzig verschiedener Stände und Gewerbe, nebst vergleichender Statistik der christlichen und israelitischen Bevolkerung Frankforts, 1855. Lauerlander's Verlag, *Frankfort*, a. m. (Tables XIX., XX., XXI., pp. 115-116).

matic generalizations. They are simply important indications that are liable to modifications according to surrounding circumstances.

Occupation.—It is generally recognized that certain kinds of occupation predispose to disease, and that there is a particular tendency on the part of those that follow them to special groups of maladies. In fact, it may be said that there exists more or less of a parallelism between the increase in industries and the increase of disease and death. With regard to the majority of occupations, disease is due less to the character of the work done than to the conditions under which it is performed, for moderate work of almost any kind, when done under favorable conditions, must be considered as in every way advantageous to the physical, moral, and mental well-being of the worker.

The conditions of occupation that most frequently predispose to ill-health are the generally poor hygienic surroundings, such as overcrowding in poorly ventilated, improperly heated, damp, and uncleanly offices and workshops; the inhalation of dust-laden atmosphere; exposure to extremes of weather, as heat, cold, and excessive moisture; and the consumption of food that is neither in quality, quantity, nor mode of preparation adequate to repair the tissue-loss consequent upon muscular and mental exertion. To this may be added the evil effects of working in cramped or constrained attitudes, particularly such as interfere with the normal action of the heart and lungs; of unusually prolonged mental exertion; and of those occupations affording constant temptation to the too frequent use of alcoholic stimulants (see Table V., page 38).

The result of these influences manifests itself in the form of either local or general reduction of vitality. In some cases there occurs a general undermining of the health of the individual; in others the effect is more or less local, and is confined to those tissues directly under the influence of the hurtful conditions, converting them into points of least resistance that serve as portals of infection.

A large proportion of industrial occupations predispose to

diseases of the lungs, through the inhalation of finely divided particles of matter in the form of dust. This tends in general to pulmonary tuberculosis and to other pulmonary troubles, principally chronic bronchitis, emphysema, bronchiectasis, and interstitial pneumonia.

TABLE V.—*Comparative mortality of liquor dealers with that of men generally* (*Ogle*):

Diseases.	Men 25 to 65 Years of Age.	
	Liquor Trade.	All Males.
Alcoholism	55	10
Liver diseases	240	39
Gout	13	3
Diseases of the nervous system	200	119
Suicide	26	14
Diseases of the urinary system	83	41
Diseases of the circulatory system	140	120
Other causes	764	654
All causes	1521	1000

According to Ogle,[1] the effect of dust-inhalation appears to differ with the physical character of the dust inhaled. That from ordinary soft wood (as inhaled by carpenters) seems to be relatively harmless, while that from hard woods (as inhaled by cabinet-makers) is much more irritating. The dusts that seem to be the most dangerous to the tissues of the respiratory apparatus are those encountered in the various textile works, mineral dusts, and the dusts of metals. Cutlers, file-workers, stone-cutters, and cotton-wool workers show a marked tendency to pulmonary tuberculosis. A singular exception is seen in the coal-miners; while constantly inhaling a dust-laden atmosphere, usually to such a degree as to result in the production of a distinct pathological condition of the lungs (anthracosis), the mortality from pulmonary consumption among miners is, according to Ogle, comparatively low.

Aside from its irritating influence dust may and often does serve as a direct carrier of infection. This is conspicuously the case when numbers of individuals are constantly together in unkept rooms. With regard to tuberculosis, the inhalation of dust contaminated with the dried sputum from consump-

[1] *Trans. Seventh Congress of Hygiene and Demography*, London, 1891.

tives is probably one of the most common channels for the dissemination of the disease; the greater frequency of the pulmonary manifestation of this malady may be cited in support of this opinion. Disease-producing agents other than that concerned in the causation of tuberculosis, notably the pyogenic bacteria, have been found in the dust of localities occupied by individuals suffering from suppurative troubles.

In the paper presented by Dr. Ogle, quoted above, attention was called to the fact that "there are some occupations of so deadly a character that life-insurance companies will have nothing to say to them, refusing to insure the life of a man engaged in them on any terms whatsoever; while, on the other hand, there are professions, or at any rate there is one profession, in which the chances of longevity are so high that an insurance company which is lucky enough to number a considerable proportion of those engaged among its clients, advertises the fact to show the general public upon what a safe basis its business is founded." Dr. Ogle presents, in illustration of the influence of employment on mortality, the following table (see Table VI.), compiled from a very large number of observations made upon men between the ages of twenty-five and sixty-five years. It must be said, with regard to such results, that they cannot be accepted as universally correct indications of the influence of occupation on mortality and disease, for many individuals in all callings are constitutionally tainted, or probably predisposed by inheritance to particular diseases, before they select their life calling; and also that the death or disease among individuals following a given trade at the time of the census may be in no way dependent upon the influence of that calling, but rather upon some one followed by them at an antecedent period.

Among the various industrial pursuits there are some that expose the workmen to influences, in addition to those generally predisposing, that are directly concerned in the causation of disease-conditions. Such occupations involve the manipulation of various chemical poisons, such for instance as phosphorus by match-workers; arsenic, by makers of certain pigments; poisonous anilins, by those engaged in their

TABLE VI.—*Comparative mortality of men, twenty-five to sixty-five years of age, in different occupations, 1881 to 1883 (Ogle):*

Occupation.	Comparative mortality.	Occupation.	Comparative mortality.
Clergymen, priests, and ministers	100	Builders, masons, bricklayers	174
Lawyers	152	Carpenters, joiners	147
Medical men	202	Cabinet-makers, upholsterers	173
		Plumbers, painters, glaziers	216
Gardeners	108	Blacksmiths	175
Farmers	114	Engine, machine, and boiler makers	155
Agricultural laborers	126		
Fishermen	143		
		Silk manufacture	152
Commercial clerks	179	Wool, worsted manufacture	186
Commercial travellers	171	Cotton manufacture	196
Innkeepers, liquor dealers	274		
Inn, hotel service	396	Cutlers, scissor makers	229
Brewers	245	Gunsmiths	186
		File makers	300
Butchers	211		
Bakers	172	Paper makers	129
Corn millers	172	Glass workers	214
		Earthenware makers	314
Grocers	139		
Drapers	159	Coal miners	160
Shopkeepers generally	158	Cornish miners	331
		Stone, slate quarries	202
Tailors	189		
Shoemakers	166	Cab, omnibus service	267
Hatters	192	Railway, road laborers	185
Printers	193	Costermongers, hawkers, and street sellers	338
Bookbinders	210		

manufacture; lead, by file-makers, painters, and plumbers; mercury, by hatters and gilders. Brass-founders and those who work in copper and zinc are subject to a peculiar form of ague—"brass-founders' ague." The continuous inhalation of irritating and irrespirable gases likewise results in diseased conditions of the air-passages—the direct results of such conditions—and likewise in constitutional poisoning. Among these agents may be mentioned the vapors of iodine and bromine, besides chlorine, ammonia, arsenuretted and phosphoretted hydrogen, nitrous and sulphurous acids, and carbon monoxide and dioxide.

Density of Population—Crowding.—It is a matter of common observation that sickness and death are most frequent in those communities where large numbers of people are crowded together in comparatively close quarters under the conditions of poverty that such an existence entails.

The accentuation of death-rate resulting from the conditions concomitant with excessive density of population, while manifest for all ages, is conspicuously evident among the very young of such a community. The following table serves to illustrate this strikingly (Table VII.).

TABLE VII.—*Showing relation between death-rate per 1000 and density of population in seven groups of districts in England and Wales (exclusive of London*[1]*) :*

Persons to 1 sq. mile	166	186	379	1718	4499	12,357	65,823
Mean death-rate at all ages . .	16.75	19.16	21.88	24.90	28.08	32.49	38.62
Mean death-rate under 5 years	37.80	47.53	63.06	82.10	95.04	111.90	139.52
Mean birth-rate per 1000 of living	30.2	32.2	35.8	38.7	40.2	37.3	37.6

In a paper presented by Dr. J. B. Russell to the Philosophical Society of Glasgow in 1888[2] there appear the results of studies made with the view of determining in how far an excessive density in population affected the death-rate of that city and to what extent such crowding was answerable for the prevalence of diseases of a special character. The author demonstrates that the death-rate in Glasgow is greatest in those districts in which the greatest number of individuals are domiciled in the smallest cubic space, and that there is a gradual decrease in the death-rate as the ratio between living-space and number of inhabitants becomes greater (Table VIII.).

[1] Consult 35th Report of the Registrar General of England (1875) ; *Supplement*, pp. clviii, clix.

[2] On the "Ticketed Houses" of Glasgow, with an Interrogation of the Facts for Guidance toward the Amelioration of the Lives of Occupants. By J. B. Russell, B. A., M. D., LL.D., *Proc. Phil. Soc.*, 1888–89, vol. xx., pp. 1 to 24 inclu.

TABLE VIII.—*The following table, compiled by Dr. Russell, shows the distribution of population and deaths in houses of various sizes:*

Size of House.	Population.	Deaths.	Percentage of Population	Percentage of Deaths.
One room	134,728	3,636	24.7	27.0
Two rooms	243,691	6,325	44.7	47.0
Three "	86,956	1,747	16.0	13.0
Four "	32,742	581	6.1	4.3
Five rooms and upward	38,647	434	7.1	3.3
Institutions	6,531	427	1.4	3.2
Untraced	. . .	289	. .	2.2
Whole city	543,295	13,439	100.0	100.0

As to the character of diseases most prevalent among the occupants of these several classes of domiciles, the same author found that zymotic, nervous, and nutritive diseases of children, accidents and syphilis in children, pulmonary and miscellaneous diseases occurred in the relative degrees of frequency indicated by the following table and chart (Table IX., Chart 1).

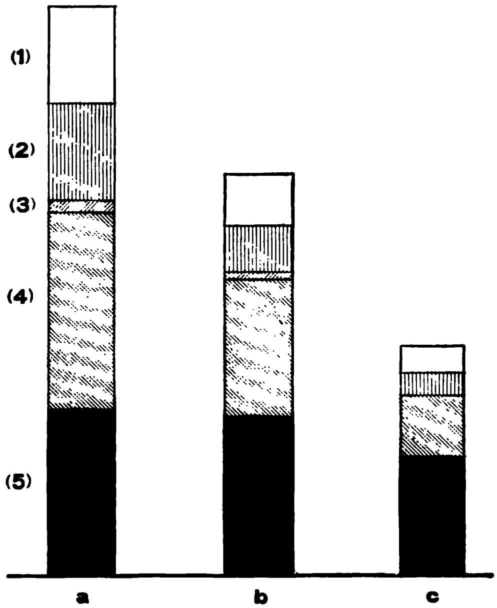
TABLE IX.—*Showing death-rates per 100,000 from certain classes of diseases in various size houses (Russell):*

	One and two room houses.	Three and four room houses.	Five rooms and upward.
Zymotic diseases	478	240	114
Acute diseases of the lungs (including consumption)	985	680	328
Nervous diseases and diseases of nutrition in children	480	235	91
Accidents and syphilis in children	32	11	
Miscellaneous unclassified diseases	700	704	590
All causes	2774	1045	1123

It would be a mistake, however, to consider that the parallelism between the various densities of population and increase of death-rate observed in Glasgow forms a basis for an infallible generalization that would be applicable to the entire population of all countries; for in a census of 28 large towns in England and in Wales (ending January 1, 1897) it was impossible to detect such constancy between density of

population and death-rate, though the communities studied were embraced between the extremes represented by Huddersfield, with a population of 90,034, a density of 8.6 persons per acre, a birth-rate of 27.7, and a death-rate of from 19.6 to 23.0 per 1000, and Liverpool, with a population of 592,991, a density of 113.8 persons per acre, a birth-rate of 31.2, and a death-rate of from 23.7 to 25.2 per 1000.

CHART I.—*Showing incidence of certain classes of diseases among occupants of various size houses (Russell).*



a, One and two room houses; *b*, three and four room houses; *c*, five rooms and upward; (1) zymotic diseases; (2) nervous and other diseases special to children; (3) accidents and syphilis in children; (4) diseases of the lungs; (5) miscellaneous diseases.

Similarly in the United States[1] we find the density of population, as expressed by persons per acre, to bear no constant relation to the death-rates in 50 large cities in this country, from which the statistics were compiled. The data

[1] See Eleventh Census of the United States, volume on Social Statistics of Cities. Diagram 3, pp. 8 to 12.

referred to were embraced between the extremes represented by New York city, with 58 persons per acre and a death-rate of 28.63 per 1000 of population, and Fall River, Mass., with 4 persons per acre and a death-rate of 24.84 per 1000 of population. Though a diminution in the number of persons per acre from New York city through the list to Fall River, Mass., was constant, still the death-rates observed in the cities of the table that fall between these extremes were most irregular, 6 being practically equivalent to that of New York city, and 34 being less than that of Fall River, Mass.

It must be said, however, that the data obtained from the 78 cities, including 28 in England and 50 in this country, do not of necessity vitiate the results of Dr. Russell's studies, for "the statement of the average density of the population of a city by no means indicates the amount of overcrowding which may exist in certain parts of it" (Billings).

It does not seem improbable that had investigations been conducted in any or all of these 78 cities along identically the same lines as those employed by Dr. Russell, results corresponding with those obtained by him could have been secured for people living in sections of these cities under conditions of overcrowding such as were observed and studied in Glasgow.

The most important factors in favor of an increasing death-rate, under conditions of high aggregation of people, are the generally unhygienic conditions under which the population exists, including filth, bad air, poor and insufficient food, inadequate clothing, deficient shelter, increased opportunities for direct infection, and the manifold, though potent, influences that are concomitant with poverty. The dissemination of infection is in inverse ratio to the distance between individuals congregated together in a habitation ; the greater the distance the less, the less the distance the greater the liability for infection to spread.

"The more crowded a community, the greater, speaking generally, is the amount of abject want, of filth, of crime, of drunkenness, and of other excesses, the more keen the competition and the more feverish and exhausting the conditions

of life. Moreover, and perhaps more than all, it is in these crowded communities that almost all the most dangerous and unhealthy industries are carried on. It is not so much the aggregation itself, as it is these other factors which are associated with aggregation, that produce the high mortality of our great towns, or other thickly populated areas" (Ogle).

Heredity.—In predisposing to disease heredity manifests its influence more through the transmission of a peculiar habit of body than by the transmission of disease itself. In the modern sense, inherited predisposition to disease implies a congenital condition that is peculiar to the idioplasm of the individuals of certain families, a condition that inclines them to this or that particular form of malady. For instance, in some families we observe a peculiar tendency to nervous diseases, as to epilepsy, or insanity; in others to cancers and tumors; in others to scrofula, tabes, and other tubercular manifestations. The rheumatic and gouty diatheses and syphilis belong also to this category. Again, families are encountered that are endowed with a marked predisposition to acute diseases, while in others there is an equally marked resistance to them. In short, the inheritance of a tendency to or immunity from disease is due fundamentally to the same processes through which peculiarities of a physical, moral, or mental nature are transmitted.

The question concerning the direct transmission of disease from parents to offspring is one over which there has been a great deal of controversy. With regard to certain diseases, such as syphilis and some of the acute infections, there can be no doubt that such a transmission occurs; but in connection with tuberculosis there is still more or less disagreement of opinion. The weight of evidence contra-indicates the probability of tuberculosis being often directly inherited, and while it is impossible to deny the intra-uterine existence of the disease, yet hereditary tuberculosis must be looked upon as a rarity. The part played by heredity in the dissemination of this disease is more often observed in the transmission of a generally enfeebled constitution, with a special predisposition to this particular form of infection. It is manifest that through

the intimacy existing between tubercular patients, particularly mothers, and their offspring that are congenitally endowed with this predisposition, there are abundant opportunities for accidental infection. Fagge calls attention to the frequent impossibility of distinguishing between hereditary and accidentally-acquired tuberculosis. On the other hand, Baumgarten favors the opinion that tuberculosis is frequently inherited, and that the virus lies dormant (is held in check) until after the period of active, infantile tissue-development, when it exhibits its pathogenic properties.

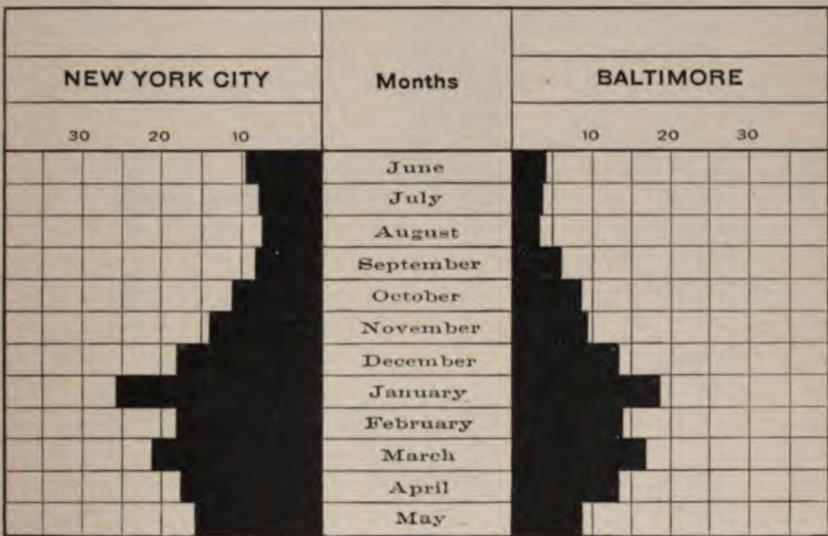
It is appropriate at this place to refer to the relative insusceptibility to disease that is occasionally observed, and to repeat that this peculiarity, like predisposition to disease, is a property that is inherent to the germ-plasm of the individuals and their progenitors thus endowed. It is not probable that the comparative immunity from, or the increased resistance to, a disease that is conferred upon an individual by a single non-fatal attack of that disease is transmitted to his offspring, any more than are the numerous other quickly acquired traits or characteristics. At least we have no evidence in favor of such a view. Important light has been shed upon this phase of our subject by the brilliant researches of Ehrlich and certain of his followers in these interesting investigations. Ehrlich has shown that acquired immunity from poisons that are in many respects analogous to those concerned in the morbid phenomena of infectious diseases is not transmissible from parents to offspring, in the way that physical and mental peculiarities are handed down; in fact, they are not inherited at all, but that for a temporary period during nursing the immune mother conveys to the suckling, through the milk, a substance that serves to protect the offspring from the disease from which the mother is immune. This protection is not permanent, but ceases with, or a very short time after, the cessation of nursing. Moreover, this protection is maternal, the father taking no part in it—a state of affairs contrary to what we know to be the case with regard to the inheritance of physical, mental, and moral characteristics.

It is more than probable that the observation of Ehrlich,

made upon animals (mice), may have an important bearing upon the phenomenon in human beings.

Season.—The fact that certain groups of diseases are most prevalent at definite seasons of the year indicates a predisposing relation between the characteristics of those seasons and such diseases.

CHART 2.—*Showing the monthly fluctuations in the death-rates from diseases of the respiratory system in New York City and in Baltimore.*



It is a matter of common observation that catarrhal diseases and, in general, those of the respiratory system are more frequent during the months of low temperature and excessive moisture than at other times in the year (see Chart 2). Whether this is due to atmospheric conditions alone, or to those in conjunction with the evil effects of crowding together in badly ventilated rooms, kept closed for purposes of warmth, it is difficult to say; but it would appear more reasonable to consider both influences together as the predisposing conditions.

During the heated months the diseases that are most prev-

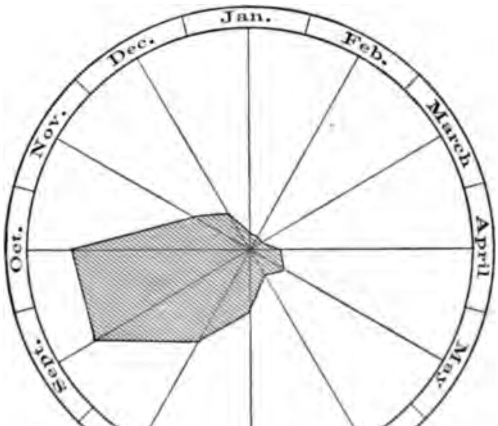
CHART 3.—*Showing the monthly fluctuations in the death-rates from diarrheal diseases in New York City and in Baltimore.*

alent are those connected with the digestive system. This is especially the case with young children, and particularly those whose food consists of materials that readily undergo fermentation under the favorable conditions of temperature afforded by the season.

In Chart 3 is shown the relative monthly fluctuation in the death-rate from diarrheal diseases in the cities of New York and Baltimore for the six years ending May 31, 1890, and it will be seen that by far the greater proportion of deaths occur in the period of excessive heat—viz., July.

The periods of greatest vegetable activity, with the subsequent period of decline, are those in which malarial diseases appear most conspicuously.

CHART 4.—*Showing by months the seasonal variation in the occurrence of malarial fever (arranged from statistics of Thayer and Hewetson).*

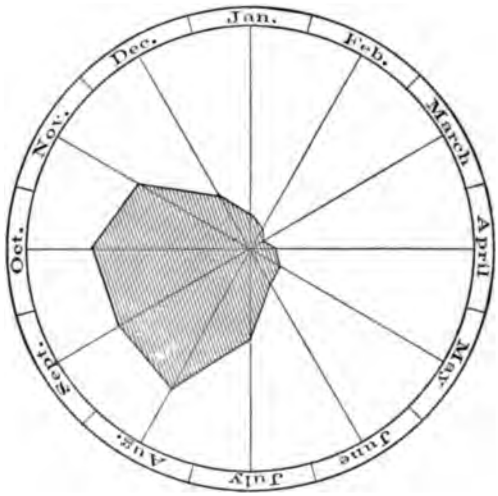


The foregoing diagram (Chart 4), arranged from the statistics of Thayer and Hewetson upon malaria in Baltimore, gives an accurate idea of the seasonal distribution of the cases of this disease:

For reasons that cannot be satisfactorily explained, typhoid fever is a disease of early autumn. While occurring to some

extent throughout the year, the period of greatest disease- and death-rates is usually during the months of August, September, and October (see Chart 5).[1]

CHART 5.—*Showing by months the seasonal variation in the occurrence of typhoid fever (arranged from statistics of Osler).*



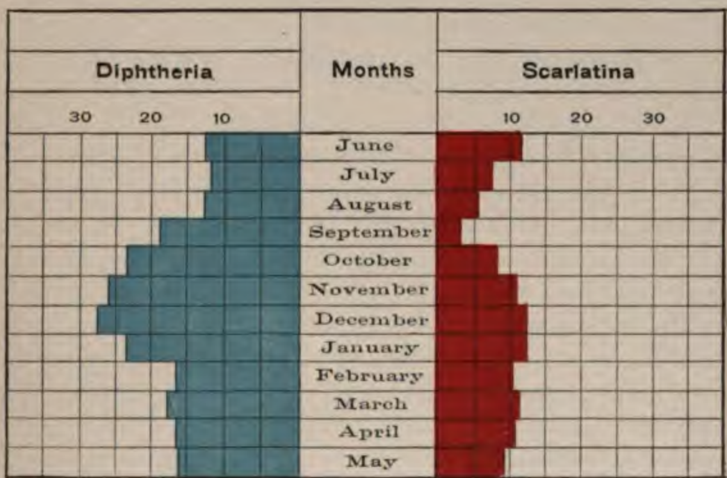
The acute exanthemata are much more prevalent from the late autumn to the early spring than at other times in the year (see Chart 6). Aside from seasonal influence *per se*, it must be borne in mind that these are the periods in which the opportunities for infection are greatest—*i. e.*, they comprise the months during which children of school age are at school, and in more or less intimate contact with one another.

For the six years ending May 31, 1890, the highest average death-rate for all ages in New York, Brooklyn, Boston, and Philadelphia occurred in the month of July, and for children under five years of age very much the highest death-rate was in this month. It is because of this striking increase in infant mortality during the hot weather that the death-rates of all our large cities are uniformly high in July and August.

[1] Compiled from Osler's "General Analysis and Summary of 229 Cases of Typhoid Fever," *Johns Hopkins Hospital Report*, vol. iv., No. 1.

With regard to seasonal influence, we find that the diseases which are conspicuously prevalent during the colder months are those that are most common in countries of high latitude—*i. e.*, having the greatest amount of cold and wet weather; while those common to our months of high temperature are closely allied to those most frequent in tropical climates.

CHART 6.—*Showing by months the average relative proportions of deaths from diphtheria and scarlatina in Philadelphia, for the six years ending May 31, 1890. Rates are per 1000 deaths from all causes.*



The Exciting Causes of Disease.—Employing the word disease in its broad sense, as comprising all departures from normal physiological function and all defects of anatomical structure, we recognize a group of chemical, physical, and vital agents that may be more or less directly concerned in its causation.

The term "direct" or "exciting," as applied to the causes of disease, is limited to those chemical, physical, and mechanical agencies that are capable of inducing abnormal conditions of the organism without the intervention of any other modifying factors; and while this term is similarly applied to the

vital agents that are instrumental in inducing definite pathological conditions and clinical manifestations, it must be borne in mind that without the intervention of predisposing conditions it is improbable that the vital causes of disease are of themselves capable, at any and all times, of performing their characteristic pathogenic functions.

For the manifestation of their particular pathogenic powers the vital agents require that the organism upon which they are to act is either by nature susceptible to their influence, or is rendered so through the action of the many detrimental agencies that serve to diminish resistance and predispose to disease.

The vital factors, while classed as the direct causes of diseases, cannot therefore be considered as standing, independent and alone, in causal relation to the processes; and while they are, in the strict sense of the word, the direct and only exciting causes of certain specific phenomena, they still require special conditions of the body that are favorable to their activity and development. These conditions usually depend for their existence upon one or more of the influences already referred to as predisposing.

Chemical Causes.—The direct chemical causes of disease may be divided into those having their origin outside the body (ectogenous), and those that are created within the body (endogenous) as a result of malnutrition, malfermentation, and other defects of metabolism and physiological function. Those originating without the body comprise the numerous organic and inorganic substances of an irritating or poisonous nature that possess the property of causing abnormal local and constitutional conditions in those exposed to their influence. The commonest of them are the various hurtful substances used in certain trades, as, for example, phosphorus, arsenic, chromic, and oxalic acids, mercury and its salts, and certain of the irritating coal-tar products. To this category belong certain drugs, such as opium, chloral, cocain, alcohol, etc., which are frequently indulged in because of their agreeable effects. The poisons of particular plants, as of *rhus toxicodendron*, or *atropa belladonna*, of *hyoscyamus niger*, of

ricinus, of *croton tiglium*, and many others, possess likewise the power of directly inducing abnormal local and general conditions. To this list must be added the poisons of venomous reptiles.

Those originating within the body (endogenous) comprise a group of compounds of whose nature we are as yet but ill-informed. They represent, most likely, intermediate products in the processes of nutrition which, through physiological defects, are not completely elaborated, and which in this state and under the existing condition of physiological enfeeblement are endowed with poisonous peculiarities; also, the ordinary end-products of tissue-activity that have accumulated within the system as a result of structural lesions of the secretory and excretory organs; and equally as important as either of the preceding, the toxic products of malfermentations often in operation within the alimentary tract.

Physical and Mechanical Causes.—The most frequent direct physical causes of disease are excessive heat, cold, and moisture, while the mechanical causes are both predisposing and, in the case of accident, exciting.

Vital Causes.—By the term vital causes of diseases are meant those living animal and vegetable parasites which, having gained access to the body, produce, as a result of their development under favorable circumstances, tissue-lesions that terminate in disturbance of important vital functions, and frequently in local or complete death of the host in which they are developing.

The disturbances that result from the invasion of the body by *animal parasites* vary with the character, mode of nutrition, life cycle, and location of the invading organism. In the one case they may manifest themselves through symptoms that point more particularly to the circulating blood, in another by more or less grave disturbances of nutrition. Again, nervous irritability, at times extreme, will be observed. In special instances marked and persistent diarrhea results; while with other forms of animal parasites the results of their presence appear to be due mainly to the mechanical irritation

caused by their lodgement in the internal viscera and in the organs of the special senses.

Thus, for instance, we observe the nutritive disturbances, the emaciation and the nervous accompaniments of the invasion of the body by the teniæ; the anemia, often extreme, that results from the activity of the host of blood-sucking strongylidæ which attach themselves to the mucous membrane of the upper part of the small intestine in the disease ankylostomiasis; the alarming symptoms that are associated with the occasional obstruction of the larger lymphatic channels by *filaria sanguinis hominis* or its embryos; the suppuration and ulceration consequent upon the lodgement of the guinea-worm in the subcutaneous tissues; and the disturbance of function that occurs from the presence of cysticerci in the central nervous system and organs of special sense.

As we shall learn later, the *modus operandi* of disease-production by animal parasites differs very materially from that of the vegetable micro-organism.

Bacteria.—For the human being, and many lower animals, the most important of the *vegetable* parasites that are directly concerned in the production of disease are the bacteria.

Bacteria are the unicellular micro-organisms that multiply by the simple process of transverse division. They are concerned in a great many phenomena other than that of disease-production. The majority of them are benefactors rather than enemies to mankind. They are nature's scavengers, being the underlying cause of all processes of disintegration and decomposition through which dead organic matter is converted into simpler compounds suitable for the nutrition of more highly organized vegetables. It is largely through the activities of bacteria that the equilibrium of the chemical composition of the atmosphere is maintained, for the amount of carbonic acid thrown into the atmosphere as a result of animal respiration alone is insufficient to meet the demands of the growing chlorophyl plants. The deficit is made up through the activities of bacteria in converting dead organic matter into this gas as one of the end-products of the process of decomposition. It is to the

activities of bacteria that commerce is indebted for important products—viz., for certain of the organic acids, and for practically its entire supply of saltpetre. In agriculture their rôle is no less important. They are the instruments through which are perfected the processes in operation in nature's great laboratory—the upper layers of the soil—which are destined to supply the food for growing crops. Through their association the leguminous plants are enabled to obtain a portion of their supply of nitrogen from the gaseous nitrogen of the air—a phenomenon which was until comparatively recently supposed to be impossible, the nitrogen of the atmosphere having always been considered to be of no biological significance.

Since the discovery of bacteria by Leeuwenhoek in 1668–1675, our knowledge of these parasites has continuously developed until we are now pretty familiar with the majority of their important peculiarities.

In addition to the functions of bacteria, mentioned above, there remains to be considered their rôle in the production of disease. Diseases that depend for their existence upon the presence of bacteria in the tissues are known as *infectious diseases*, and the process by which they are caused is known as infection. As here employed, the term infection refers more especially "to the morbific agents causing disease, and implies nothing as to the mode of transmission of these agents." A *contagious disease* is one transmissible from individual to individual by immediate or direct contact. Contagious diseases, like infectious diseases, are dependent upon the activities of vital pathogenic agents in the tissues, though in the case of the majority of the commonest contagious maladies, like small-pox, measles, scarlatina, and rötheln, the nature of these agents is unknown. *Miasmatic diseases* result from the invasion of infectious agents from without, which cannot always be traced either directly or indirectly to some other case of the same disease. Malaria may be regarded as a typical miasmatic disease.

It is evident that the term infectious, as referring to the

causation of disease, is broader than the term contagious, which relates only to the manner of transmission.

As the term is ordinarily understood *infectious diseases*, as distinct from the contagious, are disseminated indirectly—*i. e.*, in a roundabout way, by means of the water, the soil, or the food to which the morbific agents from a case of infectious disease have gained access; while the contagious diseases spread, as stated, by direct contact from a sick to a healthy individual. The miasmatic diseases follow the rule given for infectious diseases in general, though they are not always dependent upon pre-existing cases of the disease. It is manifest from what has been said, that all contagious diseases are infectious, but that many of the infectious diseases are not contagious.

Typhoid fever, cholera, and the common suppurations are examples of non-contagious, infectious diseases.

Erysipelas, pneumonia, tuberculosis, glanders, and diphtheria, though not usually contagious, may become so under favorable conditions. Small-pox, measles, scarlatina, rötheln, mumps, and varicella are infectious diseases that are notably contagious.

"Whether or not an infectious disease is contagious in the ordinary sense depends upon the nature of the infectious agent, and especially upon the manner of its elimination from and reception by the body" (Welch).

The proof necessary to demonstrate a causal relation between a given bacterial species and a disease is embodied in the postulates formulated by Koch, to the effect:

1. That the micro-organism under consideration shall always be found in the diseased tissues in such numbers, and in such relations to these tissues, that they can reasonably be assigned an etiological relation to the process.

2. That the micro-organism shall be isolated from the diseased tissue in pure cultures.

3. That the pure cultures of the micro-organism shall be capable, when inoculated into susceptible animals, of reproducing pathological lesions identical with those from which it was originally isolated.

4. That the micro-organism shall be found in the lesions produced by inoculation

It has been suggested that to these requirements be added: "That the organism be not found in other pathological conditions;" and "that it is not one of the harmless commensal species that are found in the intestine or on the skin." The inadvisability of introducing the latter two requirements is at once apparent, as we know that several pathogenic species, particularly those concerned in the causation of suppurative processes, and many of those grouped as septicemic bacteria, are at times concerned in the production of pathological lesions that differ very materially the one from the other. For instance, *streptococcus pyogenes* may under one set of conditions cause erysipelas, under another phlegmonous inflammation; *micrococcus lanceolatus* is known to be the cause of acute lobar pneumonia, of acute endo- and pericarditis, of peritonitis, of cerebrospinal meningitis, of suppurations of the middle ear, and of circumscribed abscess-formation. The members of the group of hemorrhagic septicemia bacteria, while usually instrumental in producing an acute general infection, may under special circumstances cause a condition that is conspicuous for its local manifestations, and the extent of general infection may be very insignificant.

With regard to the so-called "harmless commensal" species, we know that under various circumstances they may exhibit pathogenic properties. A conspicuous illustration is found in the common bacillus of the colon (*bacillus coli communis*)—an organism present in the colon of all human beings and of many lower animals. Under ordinary circumstances these organisms exist as harmless saprophytes, but under conditions that bring about lesions of the intestinal mucous membrane, or those causing general reduction of vital resistance, this organism may exhibit disease-producing properties.

In the mouth-cavity of a very large proportion of normal human beings *micrococcus lanceolatus* (pneumococcus) is found. This organism, like the one just mentioned, may prove to be of no danger to the host in which it is living, or

it may, through the aid of predisposing factors, become the cause of a variety of pathological conditions.

In the skin of many individuals the pyogenic cocci may be demonstrated. These too may continue to exist as innocent saprophytes, or they may, under favorable conditions, exhibit their disease-producing powers.

We see that a given species may, with varying conditions, cause lesions of a dissimilar kind; and we also see that the so-called "innocent, commensal" species may at times take on pathogenic properties.

With regard to the postulates of Koch, it is manifest that their fulfilment is possible only in a limited number of cases.

Some of the most important diseases that are known clinically to be of an infectious nature have thus far eluded all efforts to discover their causative factors. In others micro-organisms may be constantly found, and these micro-organisms may be exclusively found in these diseases, though no success has followed the efforts to isolate and cultivate them. In still other groups definite bacterial species may be found, isolated and cultivated, and yet the reproduction of the disease by inoculation into lower animals has either been impossible, or only in part satisfactory, owing to the difficulty of faithfully reproducing in animals used for inoculation the clinical symptoms and pathological lesions, by which the diseases from which the bacteria were isolated are characterized in man.

There are many important diseases to which mankind is liable that do not occur spontaneously and cannot be produced in animals that are used for purposes of experimentation. There is no evidence that animals ever suffer spontaneously from such diseases as typhoid fever, Asiatic cholera, leprosy, syphilis, malaria, yellow fever, small-pox, measles, etc., and it is seen to be in the main impossible, even in those animals that are in general most susceptible to infection, to produce by inoculation clinical and pathological manifestations that are a correct reproduction of those that characterize these diseases in human beings.

For the group of septicemias that occur in animals, such

as chicken cholera, rabbit septicemia, anthrax, and mouse septicemia; for certain suppurative processes; for diphtheria, for glanders, for gonorrhea, and for tuberculosis, the proof is conclusive, and all the requirements have been met; but for cholera, typhoid fever, malaria, and leprosy, and for amœbic dysentery, and certain other protozoal diseases, the postulates of Koch have only in part been fulfilled. It should be said, with regard to Asiatic cholera and typhoid fever, that by particular methods of experimentation pathological conditions somewhat analogous to those seen in man have been produced, but in general the results thus obtained are not fairly comparable, either etiologically, pathologically, or clinically, with those observed in human beings affected with these maladies. In one or two instances cholera has occurred in human beings who have purposely or accidentally swallowed cultures of the cholera spirillum.

There are a number of infectious diseases, including those dependent upon the presence of protozoa in the tissues, in which only the first of the requisite proofs has been established. In these diseases there are constantly and exclusively present micro-organisms that are capable of microscopical demonstration, but of which none have been isolated in culture, and the diseases have not been satisfactorily reproduced in animals. The most important of the group are malaria, amœbic dysentery, relapsing fever, leprosy, and, possibly, syphilis. The majority of the commonest infectious diseases have eluded all efforts to discover their specific causative agent. Of these may be mentioned yellow fever, measles, scarlet fever, small-pox, varicella, mumps, dengue, and typhus fever.

As regards their life-processes, bacteria lead either a saprophytic or a parasitic existence. A "saprophyte" is one that grows upon dead organic matter—that is, it develops without a living host; while a "parasite" is one that depends for its existence upon the conditions offered by either a living animal or plant, in or on which it develops. There are species that live with—*i. e.*, that are commensal with—both animals and plants. They are saprophytic in that they

do not live at the expense of their host and have no deleterious action; in fact, they are frequently of importance to their host by aiding in the performance of normal physiological functions, through their symbiotic association.

Both saprophytes and parasites have their *obligate* and their *facultative* varieties. In this sense the term "obligate" as applied to a saprophyte implies that it can live *only* on dead matter; when applied to a parasite, that it can develop *only* within a living host. The designation "facultative" as applied to a parasite or a saprophyte implies that these organisms possess the power of leading either a parasitic or saprophytic form of existence, according to circumstances.

The parasitic bacteria that are concerned in the production of those diseases in which all the postulates of Koch have been fulfilled are *facultative* saprophytes, as it is possible to cultivate them outside a living host on dead organic nutritive media. Had they been *obligate* parasites this would have been impossible, and it may be due to their obligate nature that certain, presumably present, species of bacteria elude our efforts to cultivate them.

This power of adaptability to surrounding conditions which is common to the facultative saprophytes; the fact that after prolonged existence under saprophytic conditions many of them experience modifications in those pathogenic functions that characterize their parasitic life; the fact that by a variety of artificial procedures modifications of other important biological functions may be induced, have served as a basis for occasional discussion relating to the fixity of what are usually considered type-characteristics, and the advisability of considering the different specific varieties of bacteria as definite and distinct species.

As generally employed by biologists, the term "species" implies "an individual which differs, or collectively, those individuals which differ specifically from all the other members of the genus, and which do not differ from one another in size, shape, color, and so on, beyond the limits of individual variability, as those animals and plants which stand in the direct relation of parent and offspring, and perpetuate certain

inherent characteristics intact or with that little modification which is due to conditions of environment."

In the sense of this definition the individual peculiarities of the recognized pathogenic bacteria are of sufficient constancy to justify the opinion that they represent functions of definite species.

Nevertheless, variations both of form and function are known to occur under the influence of a variety of conditions. Variations in function are, as a rule, much more lasting and more frequently encountered than are variations in form.

The majority of the variations that one observes are the result of injurious conditions concomitant with growth under artificial circumstances, such, for example, as prolonged saprophytic existence of facultative saprophytes; growth under unsuitable conditions of nutrition; the influence of deleterious agents, as oxygen, light, heat, and hurtful chemicals; association with antagonistic species; the influence of the products of growth of other bacteria; and the harmful influence of certain animal fluids and tissues.

The variations in form most commonly seen are temporary, are the result of unfavorable conditions of life and, as a rule, disappear under the influence of normal environment. The commonest of such morphological changes are those indicative of degenerative processes in the bodies of the bacteria themselves, resulting in the occurrence of the so-called "involution forms."

It is possible by prolonged heating and by the application of particular chemicals to deprive certain bacteria of their power to form spores. By special methods of cultivation short bacilli have been induced to grow as longer threads. The color characteristics of certain chromogenic species have been modified, and under varying conditions of nutrition fluctuations in the function of fermentation are observed. By artificial processes, as prolonged heating to 42° C., and by the action of certain chemicals in a dilute form, *bacillus anthracis* may be in part or wholly robbed of its pathogenic properties. On the other hand, exaltation in virulence is

often seen to follow the repeated passage of attenuated varieties of bacteria through susceptible animals. The same result sometimes follows the mixing of attenuated varieties with other species of bacteria and with certain chemical agents.

As a general rule, the structurally modified species revert to their normal morphology when placed under favorable conditions. This is true also for certain functional modifications, though those that appear slowly after the continued action of modifying influences—such, for instance, as prolonged heating—are apt to be lasting and, in some cases, hereditary.

That modifications of important characteristics appear naturally there can be no doubt. The most conspicuous example of this is the loss of virulence experienced by many pathogenic species when expelled from the diseased body and forced to compete for existence with the host of normally saprophytic forms under the adverse circumstances offered by the soil, water, and other places in which they find themselves. Striking examples of this are seen in the bacillus of typhoid fever, the colon bacillus, the spirillum of Asiatic cholera, the streptococcus of erysipelas, *micrococcus lanceolatus* (pneumococcus) and the group of organisms concerned in septic infections.

Notwithstanding all this there has not as yet been presented any trustworthy evidence to the effect that by any of the known natural phenomena or artificial processes one definite bacterial species, as recognized by the available methods of study, may be changed into another, such, for instance, as the anthrax into the subtilis bacillus or the colon bacillus into that causing typhoid fever, though intermediate varieties suggesting probable graduations in certain peculiarities may frequently be encountered

SECTION II.

THE TRANSMISSIBLE DISEASES.

THIS section comprises brief sketches of the commoner transmissible diseases, with a summary of points that are of importance to the hygienist, such as the causation, modes of dissemination, portals of infection, prophylaxis against, and the geographical distribution of such diseases.

In this summary no attempt is made to treat of the various infectious diseases in full. The object is to emphasize that knowledge which is essential to a rational prophylaxis against their spread—such, for instance, as that relating to the agents concerned in their causation; when and where such agents are to be sought for; the manner in which they are expelled from the diseased and received by the healthy body; the steps to be taken to prevent the dissemination of the morbific factors; the geographical distribution and the racial susceptibilities to and immunity from such diseases.

TYPHOID FEVER.

Cause.—The bulk of the evidence points to *bacillus typhosus* of Eberth and Gaffky as the specific cause of this disease.

Bacillus typhosus is a short, actively motile, flagellated, non-spore-forming, non-liquefying rod with rounded ends (Fig. 1). It does not possess the property of fermenting glucose or lactose, nor of producing indol as a product of its growth in the ordinary nutrient media. It does not coagulate milk. It is destroyed in ten minutes by a temperature of 60° C. It is not destroyed by freezing. When inoculated

into animals the results are irregular. Most frequently this has no effect. Occasionally evidences of intoxication rather than genuine infection are obtained. Exceptionally, a specimen will be obtained of so high a degree of virulence that it possesses the property of infecting. By none of the ordinary methods of inoculation are conditions produced in animals

FIG. 1.—Bacillus typhosus: *I*, stained by ordinary methods; *II*, flagella stained by Löffler's method.

that are in any way, either clinically or pathologically, comparable to those found in the human being suffering from typhoid fever. By a few investigators lesions of the intestine similar to those seen in the human being are claimed to have been produced by special methods of inoculation in particular species of animals. As intimated, these results are by no means common.

Mode of Dissemination.—Since the specific micro-organism causing the disease is contained in the discharges from the bowels of typhoid patients, and is apparently at times present in the urine also, it is manifest that all substances with which these matters come in contact may become specifically contaminated and be capable of conveying the disease.

Typhoid fever is disseminated in a variety of ways, but most frequently through the water, the soil, and through

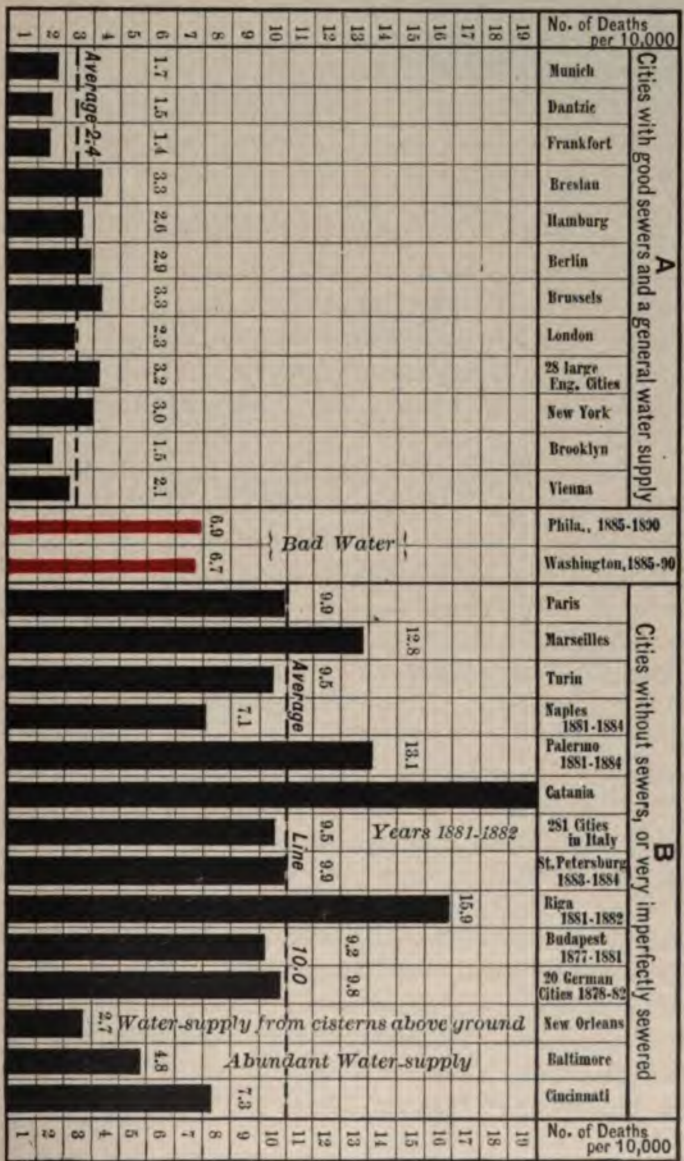


CHART 7.—*Deaths from typhoid fever to each 10,000 inhabitants in sewered and unsewered cities. Average of five years, 1880–84, unless otherwise stated.*

Charts 7 and 8 are from "The Influence of Sewerage and Water-Supply on the Death-Rate in Cities," by Erwin F. Smith, Supplement to the *Annual Report of the Michigan State Board of Health*, 1885.

green vegetables, salads, etc., that are eaten raw and that have been fertilized with human manure. It is not infrequently disseminated by milk which has become infected as a result of the use in the dairy of water polluted with typhoid evacuations. Attention has recently been directed to raw oysters as a possible disseminator of this disease. The outbreak of typhoid fever at Wesleyan College, to which Conn directed attention,[1] is believed by him to have been caused by the use of oysters that had been "fattened" in waters polluted with typhoid evacuations; an outbreak of the disease in England is believed by Broadbent[2] to be due to the same cause; and numerous experiments point to the possibility of the disease being conveyed in this way.[3] The refuse of food that has been used by typhoid patients should be looked upon with suspicion, and should under no conditions be eaten by others in attendance.

There is no evidence that the disease is disseminated through the air. Milk and other foods may be infected by insects that have been in contact with fresh typhoid stools, and thus become means for conveyance of the infection.

Portals of Infection.—The disease is not contagious. It is not spread by breathing the same atmosphere with a typhoid patient.

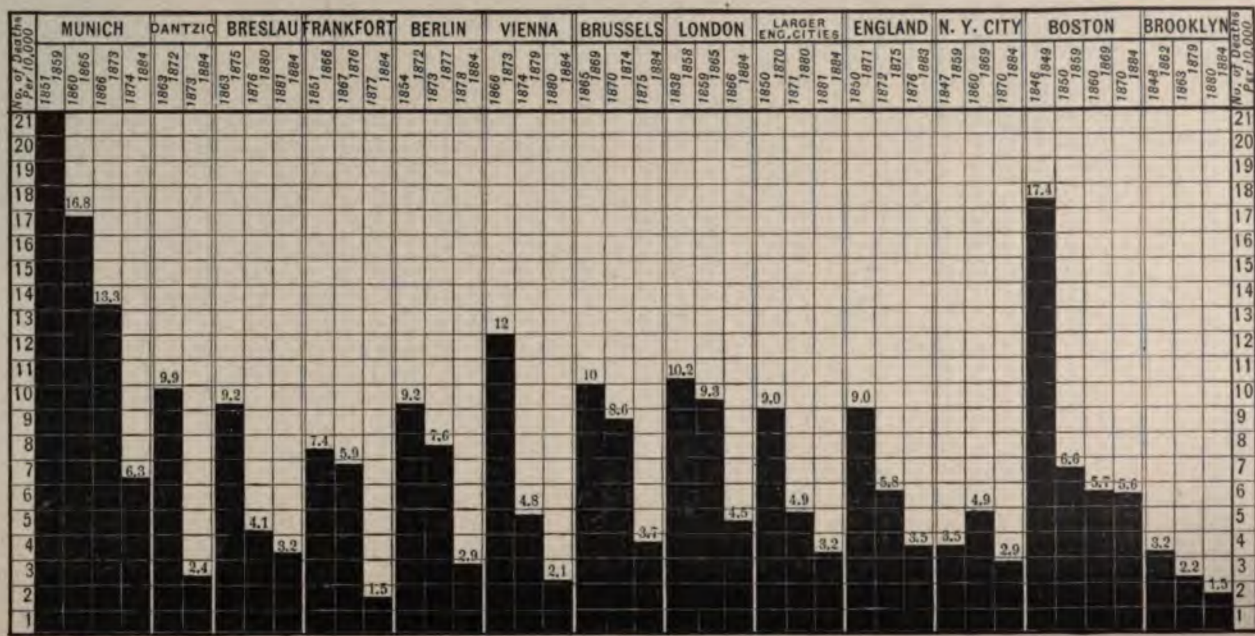
Infection occurs by way of the alimentary tract—*i. e.* it results from actually swallowing materials that have come directly or indirectly from the bowels of individuals affected with the disease. We have no evidence that it occurs in any other way.

Prophylaxis. It is now generally recognized that the most potent factors in diminishing the widespread occurrence of this disease in communities are an unpolluted general water supply and a reliable system of sewage disposal (see Charts [illegible] and 8). The conspicuous decline in the mortality from typhoid fever that has followed the adoption of such

[1] [illegible], Dec. [illegible], 1894 [illegible], Jan. 12, 1895.

[2] [illegible] Report of Medical Officer of Local Gov. Board, 1894-95 [illegible] Cartwright Wood; also [illegible], Nov. 27, 1895.

CHART 8.—*Deaths from typhoid fever to each 10,000 inhabitants before, during, and since the introduction of sewerage and water-supply.*



measures in many of the larger cities, particularly in Europe and Great Britain, and in a few in this country, can leave little room for doubt as to the correctness of this view (see Chart 8).

In districts where the water-supplies are obtained from shallow wells there is probably no more active cause of the spread of this disease than pollution of the soil by cesspools and privies. In such localities the soil is often saturated with the contents of privies into which not only normal intestinal contents find their way, but also the evacuations of individuals suffering from this malady. It is therefore plain that the most important domestic prophylactic measures consist in the disinfection of the bowel-discharges from all suspicious cases of intestinal trouble, and the subsequent disposal of such discharges by some method that will remove them quickly and completely from the neighborhood of human habitations. This latter is to be accomplished in cities only by means of an efficient sewage system. In the country, where sewers do not exist, reliance must be placed in the disinfection of the stools (see chapter on Disinfection) and their final disposal *upon* the soil.

The domestic prophylactic measures consist, again, in careful disinfection of all intestinal contents before they are finally disposed of. This point cannot be too strenuously urged; as the stools of typhoid patients are the only known source of the disease, and as they are easily rendered inert, a great deal may be done in reducing the frequency of the disease by faithful attention to this point.

All body- and bed-clothing of the patient that has become soiled by intestinal discharges is to be removed at once and placed directly into a covered vessel, preferably one containing a cold solution of carbolic acid in water, the strength being 3 per cent. The towels, napkins and, in fact, all wash-goods when taken from the patient are to be similarly treated. They should remain in this solution for about two hours, when they may be laundered in the usual way.

If it is desirable to subject linen or muslin articles that are stained by blood or fecal matters to the disinfecting action of

either steam or boiling water, the stains should first be removed. This is easily accomplished by soaking them for about two or three hours in a *cold* 3 per cent. solution of carbolic acid and finally rinsing them thoroughly in a fresh portion of the same solution. This removes all stains. The articles may then be subjected to further processes of disinfection, if desired, by either boiling or steaming in a steam disinfector. Unless the stains are first removed, the action of moist heat renders them permanent, and they cannot be subsequently removed by any of the ordinary processes of laundering.

The eating utensils, of which the patient should be supplied with a set for his exclusive use, are to be scalded thoroughly with boiling water after each meal. The refuse of meals is to be at once scalded or burned.

After attending the patient the nurse should carefully rinse her hands in a 1 : 1000 solution of corrosive sublimate, after which they should be thoroughly washed in warm water and soap, and scrubbed with a nail-brush.

All valueless articles used about the patient, as the toilet paper, or rags used in wiping or bathing the nates, should be burned as soon as used.

In times of epidemic or in localities in which the disease is more than usually prevalent, all water and milk should be heated to from 60° to 70° C. for at least fifteen minutes before being drunk. It should be cooled, not by the addition of ice, but by placing it in the ice-chest in a vessel that has been previously scalded.

In localities where human manure is used as a fertilizer, all green vegetables used as salads should be regarded with suspicion. Since the organism causing the disease is easily destroyed by heat, there is no more useful aid to prophylaxis than the use of *boiling* water.

Geographical Distribution, Season, Sex, Age, etc. —The disease occurs in all countries, perhaps more frequently in temperate than in countries presenting the extremes of atmospheric heat and cold. It is a disease of late summer and early autumn, the greatest number of cases usu-

ally occurring between the latter part of July and the early part of October, though a few cases may be, and often are, irregularly scattered throughout the year.

Men are somewhat more frequently affected than women. It is a disease of youth and early adult life, being comparatively infrequent before the age of fifteen and after forty-five years.

Though endemic in all countries, it is not unusual to encounter local epidemics, and the most frequent cause of such epidemics is the domestic use of polluted water, though infected milk has on various occasions been shown to be the disseminating factor.

It may serve a useful purpose to present the details of several of the classic, water-borne outbreaks, in order to illustrate, the lines along which evidence pointing to their causation has been accumulated.

Epidemics of Typhoid Fever.—The Lausen Epidemic.—Conspicuous among them may be mentioned the oft-cited outbreak of typhoid fever in Lausen in Switzerland. This village, prior to the outbreak to which reference is made, had never been visited by an epidemic of typhoid fever, and for years there had not been known a single sporadic case of the disease. In 1872 typhoid fever appeared in the village, and before its disappearance about 17 per cent. of the inhabitants had been attacked.

Lausen is situated in the province of Basle just north of the mountain ridge Stockhalden (Fig. 2), which separates it from the Fürlerthal. In a solitary farm-house in this valley lived a peasant, who was attacked with typhoid fever on June 10, after having been away on a visit. Between June 10 and August a girl and the farmer's wife and son, all inmates of the same house, were attacked with the same disease. On August 7 the disease appeared in Lausen and almost simultaneously 10 individuals were stricken down; during the next ten days 57 persons were affected; by the end of the fourth week the epidemic numbered 100 cases, and at its close in October 130 of the 780 residents of the town had suffered from the disease. In addition to this, 14 children,

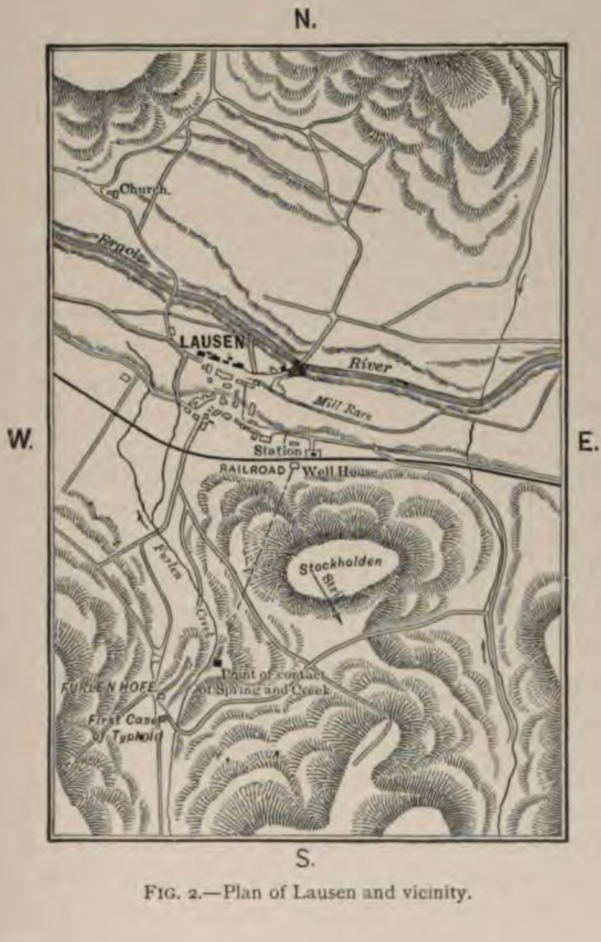


FIG. 2.—Plan of Lausen and vicinity.

who had been spending their holidays in the town, developed the disease after their return to school.

The cases were pretty evenly distributed throughout the village, with the exception of six houses. These six houses had their own private wells from which their domestic water-supply was drawn. This fact directed suspicion to the source from which the town drew its water-supply. This supply came from a spring at the foot of the north side of the Stockhalden ridge which separated Lausen from the farm-house to which reference has been made. Observations upon a brook in the Fürlerthal, near which the peasant lived, and of the water-supply of Lausen gave rise to the suspicion—ultimately proved to be correct—that there might be a direct communication between the two. It had been noted that, ten years previously, a hole had spontaneously formed in the soil, a little below the farm-house, and that whenever the meadows below this hole were inundated by water from the Fürler the volume of the spring supplying Lausen became rapidly augmented.

The Fürler was in direct communication with the closets and dung-heaps of the affected house. The intestinal evacuations from the inmates were thrown into it, and their soiled clothing was washed in it, and it was with the waters of this brook that the meadows had been inundated from the middle to the end of July. The epidemic began at Lausen about three weeks after this inundation. To fix further the connection between the polluted water of the Fürler and the spring at Lausen, Dr. Hägler, who investigated the case, made an experiment which demonstrated that the epidemic in Lausen was the outcome of the use of water polluted by the dejecta from the patients in the Fürlerthal, on the other side of the mountain ridge. The hole near the farm-house in the Fürlerthal was opened, and the brook led into it; after *three* hours the volume of water given out by the spring at Lausen *was doubled;* about 18 hundred-weight of common salt was now poured into the hole, and in a very short time the water at Lausen ga[illegible] chemical reaction of this salt, the [illegible] reased until

analysis showed the amount of salt present to be about threefold of what it was at the beginning.

The experiment cleared away all doubt as to the means by which the disease reached Lausen, and the channel through which it was disseminated.

The Wittemburg Epidemic.—Still another example of the dissemination of typhoid fever through drinking water, which is of interest not only for this alone, but is especially instructive as an illustration that this disease can arise only from the use of waters that are contaminated with the *specific causative agent of typhoid fever*, and that the use of water not so contaminated, but *equally foul* in so far as other pollutions are concerned, does not result in the appearance of this disease.

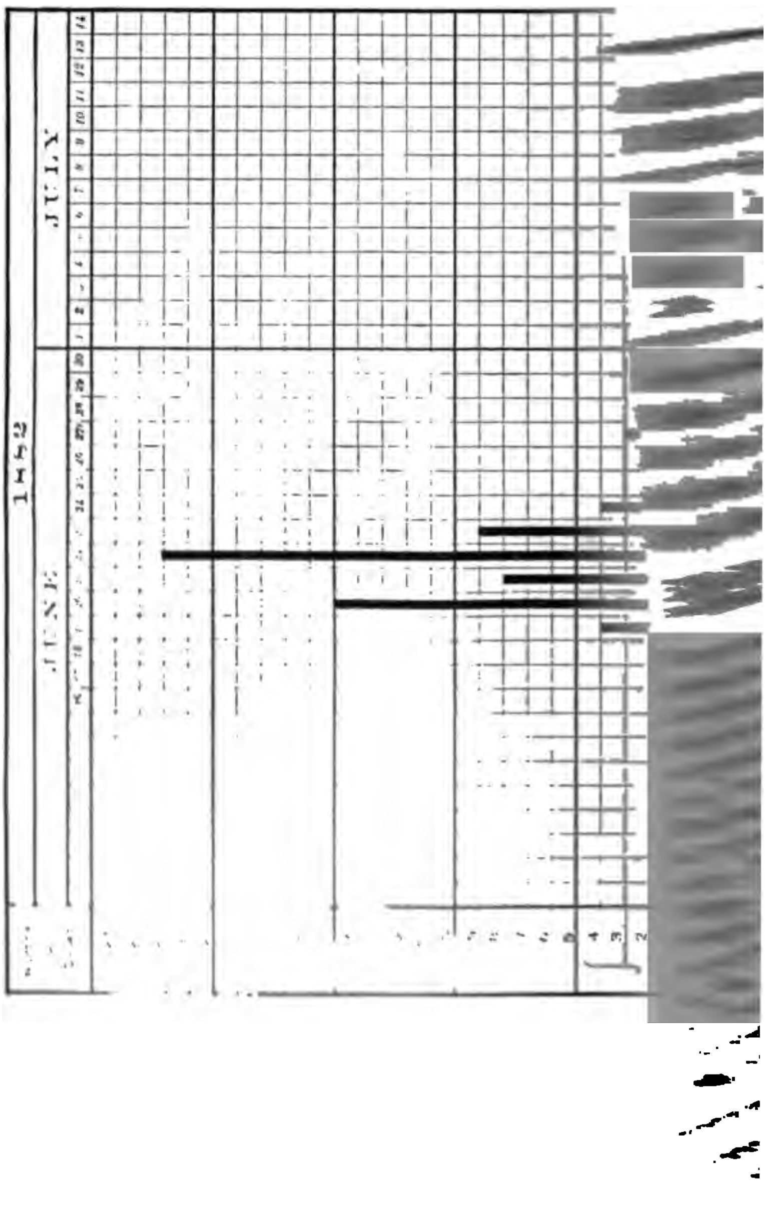
The case in point is recorded by Gaffky[1] and is as follows:

In June, 1882, there appeared among the privates of the 3rd Brandenburg Infantry regiment located at Wittemburg, an epidemic of typhoid fever which, by virtue of its sudden appearance and dissemination (Chart 9) and its limitation to one battalion of this regiment, offered a favorable prospect for the discovery of the causes underlying its existence.

The three companies of this battalion, in which the disease broke out, numbered 386 men, 226 of whom were quartered in the arsenal, while the remaining 160 were quartered in private houses in the town.

Of the 160 men quartered in 17 private houses in the town, 24 suffered from typhoid fever, while not a single case occurred among the other inmates of these houses. Indeed, during the course of the epidemic not a single case was reported among the citizens of the town. From this it seemed probable that the cases of typhoid fever that had occurred among the soldiers quartered both in the barracks and in the town had been infected from the same source. After careful inspection of all other possible channels through which the men could have become infected, the water-supply was finally subjected to investigation.

[1] **Gaffky**: *Mittheilungen aus dem Kais. Gesundheitsamte*, 1884, Bd. ii., S. 410.



. .) . . . ing the incidence of typhoid fever at Wittemburg.

The water used by the troops was supplied by two wells, one situated in the yard of the barracks near a privy, the other just outside the barracks yard in the neighboring " --omeisterstrasse. Upon chemical analysis and careful :, both wells revealed considerable contamination, ecause of the more agreeable taste of the water in utside the barracks yard, in a neighboring street, nore commonly used for drinking purposes by both d citizens than was the water of the well within the ard.

ation showed that some time prior to the outbreak, ejecta had been thrown into the barracks privy, tuated about 50 feet north of the well in the yard, examining the walls of this privy, which were nd had hitherto been supposed to be proof against two cracks of appreciable size were found, through ontents had leaked.

ta between this privy and the well were for the of coarse sand and gravel, and it is therefore at the contents of the privy had oozed through il into the well. This was facilitated probably by s:

owness of the water in the well; (2) the increased water which was drawn from the well at that he year, amounting practically to an aspiration ter in the surrounding soil; (3) the direction of of ground water, which was found to be from the l the well.

will be seen the relation between the privy and well, while in Fig. 4 will be seen the relation barracks and the houses of the town, particularly in which soldiers affected with typhoid fever those houses in which cases of the disease had 1, the year preceding. From the general con- evident that suspicion pointed more strongly to the well in the yard of the barracks than to that n the neighboring Burgomeisterstrasse, for the evidently polluted, was less likely to be specif-

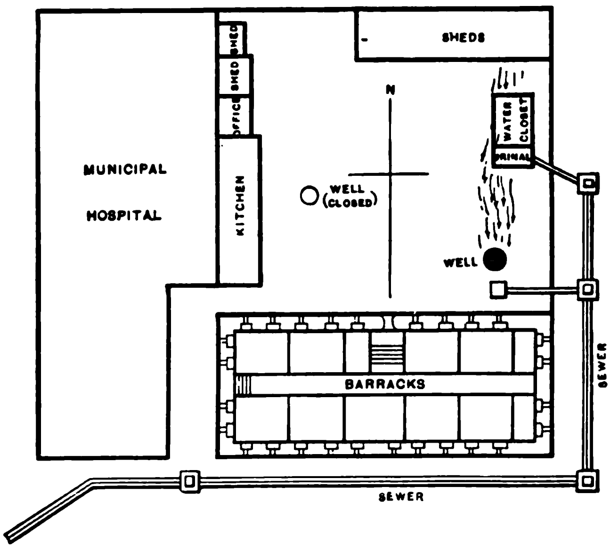


FIG. 3.—Plan of barracks at Wittemburg, showing the relation between buildings and well.

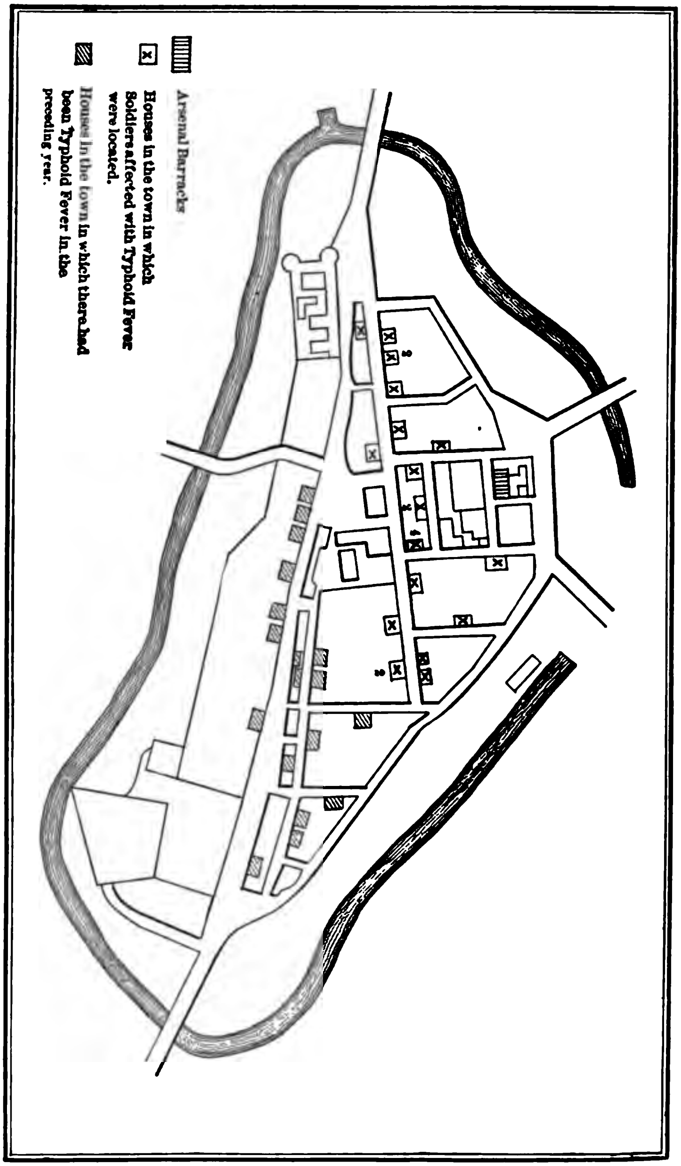


FIG. 4.—Plan of Wittemburg.

ically polluted, for, as stated, there were no cases of typhoid fever among the citizens using water from this well; and as it was more agreeable in taste than the water from the barracks well it was customary for the officers, among whom likewise no cases of typhoid fever occurred, to use this water, though in general it is very probable that the officers drank much less water than did the privates.

The water from the well in the yard of the barracks, though of a very poor character, was nevertheless occasionally used for drinking purposes by the men.

It was *always* used for washing dishes, clothing, and particularly for rinsing beer-mugs and canteens, none of which are ever dried after washing, but only allowed to drain.

Though subjected to a most careful bacteriological analysis by Gaffky himself, no typhoid bacilli were detected, a result that might have been expected *a priori*, for by the time the analyses were made (at about the end of the epidemic) the organisms which had been present at the time of the pollution, through which the battalion became infected, had disappeared. The pollution was not continuous, and in all probability had lasted for but a few days, when it did occur.

This negative evidence, however, by no means weakens the ground taken by Gaffky in believing this well to have been the source of infection.

The Epidemic at Plymouth, Pa., in 1885.—In the spring of 1885 the mining town of Plymouth, Pa., of about 8000 to 9000 inhabitants, was visited by an outbreak of typhoid fever of explosive violence. The sudden appearance of the epidemic, its rapid spread, and the ultimate demonstration of the underlying cause, make it one of the most instructive of the many cases of this kind that have been recorded. From 60 to 100 new cases occurred daily, and on one particular day 200 fresh cases were reported. At least 1000 of the 9000 inhabitants were stricken down with the disease.

The circumstances surrounding this outbreak were of such a character as to point directly to the drinking water as the channel of infection.

The facts that were elicited upon inspection of the town

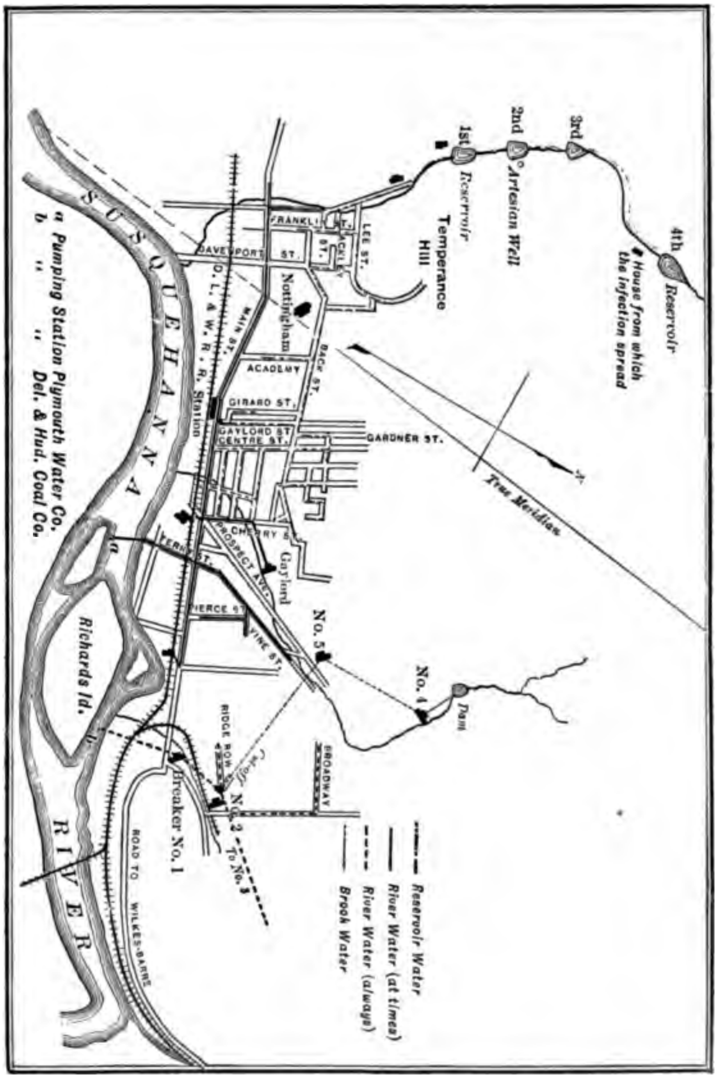


FIG. 5.—Chart of Plymouth, Pa., showing sources of its water, and the distribution of the polluted supply (line in red).

and its surroundings were as follows: Conspicuous among the data recorded was the fact that while the disease was generally distributed through the town, it occurred, practically, *only in those houses that received their water-supply from one special source*—*i. e.* the general water-supply of the town that is obtained from a series of reservoirs situated along the course of a rapidly-flowing mountain stream that skirts the southwest margin of the borough. From these reservoirs it is distributed in pipes in the usual way. It was also noticed that in those houses receiving their water from other supplies or those having private wells, either no cases of the disease occurred or where they did occur it was only among the members of the family who drank of the general supply while away from their homes, during the business hours of the day. During the course of the epidemic it was not uncommon for the disease to appear in almost every house on one side of a street supplied with water from the reservoirs, while in those on the opposite side having private wells not a case appeared.

In short, the disease appeared *only* in those persons who drank of the hydrant water from the reservoirs along the course of the stream mentioned.

Upon further investigation it was discovered that between the third and fourth reservoirs and about forty feet from the banks of the stream (Fig. 5) was located a solitary house in which there had been, some weeks prior to the outbreak, a case of typhoid fever. The facts that were elicited were these: One of the occupants of this house, a man, had visited Philadelphia on December 25, 1884, and while there had contracted the disease. He returned to his home in January and was ill with typhoid fever for many weeks. During the course of his illness, according to the statements of the nurses and attendants, the dejecta that were passed during the night were thrown upon the snow within a few feet of the stream supplying the town with drinking water, while the daily evacuations were emptied into a privy the contents of which lay upon the surface of the ground. From March 21 to March 23 the temperature of the atmosphere became suf-

ficiently elevated to melt the snow that up to this time had been frozen hard, and during the early days of April there were frequent warm showers. In consequence of these atmospheric conditions the entire mass of dejecta that had been passed by the patient during the course of his illness was washed directly into the stream supplying the reservoirs from which the town obtained the largest part of its water.

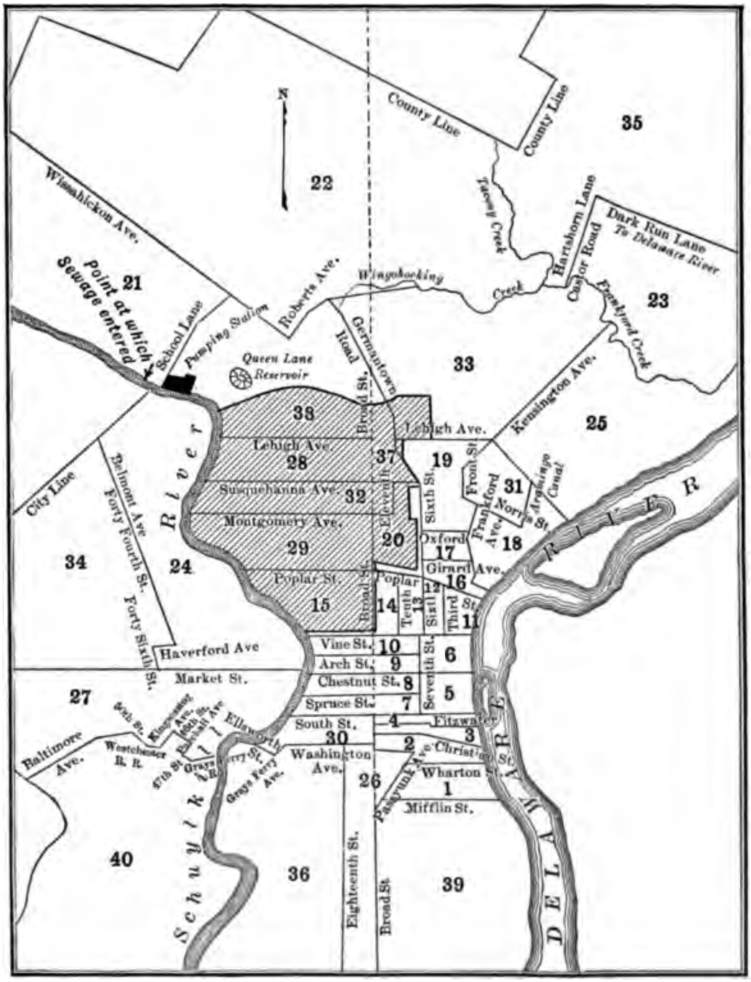
The amount of pollution was therefore exceptionally great, and the disease-producing elements must have been disseminated by means of the water very shortly afterward; at all events, the evidence that was obtained shows that the first cases of the epidemic appeared within from two to three weeks—the period of incubation of typhoid fever—after the polluted water had been distributed through the town.

The accompanying is a chart of Plymouth, with sources of its water, and the distribution of the polluted supply marked —·—·—· (page 79).

The Outbreak in Philadelphia During the Winter of 1897–98.—The city of Philadelphia receives its water-supply in large part direct from the Schuylkill river, a more or less grossly-polluted stream that traverses a thickly-populated section of Pennsylvania, and finally unites with the Delaware river to the south of the city.

During December, 1897, January, and a part of February, 1898, the weekly returns of the Health Officer of the city revealed the fact that typhoid fever had suddenly appeared in Philadelphia to such an extent as to be fairly regarded as epidemic; the number of cases reported between November 27, 1897, and March 1, 1898, having been 1927 as compared with 628 cases for the same period of 1896-97 and as against a weekly average of 40 cases for the eight weeks preceding December, 1897. In short, during the period of greatest prevalence the number of cases reported weekly was somewhat over three times as great as under usual conditions.

Upon locating these cases the increase was found to be general throughout the city, but the majority of the cases (about 65 per cent.) occurred within a sharply-circumscribed area in the northern section of the city that embraces princi-



Map of Philadelphia, with ward boundaries.

pally the 15th, 20th, 28th, 29th, 32nd, 27th, and 38th wards (see shaded area on Map, page 83), having a population roughly representing only about one-fifth of the entire population (census 1890).

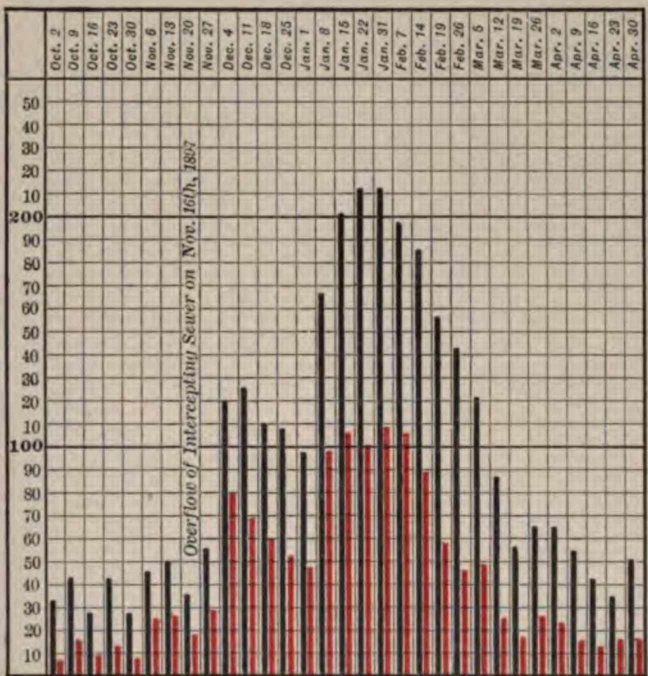
As soon as this state of affairs became evident a careful inspection, including chemical and bacteriological analysis of the milk and water-supplies of this section especially, was ordered by the Board of Health. The results of careful studies upon the problem by laboratory methods shed no important light upon the origin and mode of dissemination of the disease.

It was clear to those engaged upon the investigation[1] that the cause of the outbreak must have been operative at some period antecedent to the epidemic outbreak of the disease; that infection of a large number of persons must have occurred simultaneously and probably through the same channel; and that, taking four to six days as the time necessary to recognize the disease and notify the Board of Health, and seven to ten days as the period of incubation of typhoid fever, infection must have occurred during the week ending November 20, 1897.

On referring to the events of this week it was found that on the afternoon of November 16 there was suddenly deposited into the Schuylkill river, as a result of the overflow of the large intercepting sewer that carries the sewage of a great portion of northern Philadelphia, a large volume of raw sewage. The point at which this occurred was located on the same side of the river and but a short distance up stream (a few hundred feet) from the intake of the pumping station that supplies water to the Queen Lane Reservoir. At the time of the accident and for about two hours afterward, the pumps were engaged in filling this reservoir, and a very large portion of the grossly-polluted water must have been pumped directly into it. The pumps at the stations located further down the stream were stopped a few hours after the accident "because the water was discovered to have a peculiarly bad

[1] In this connection I wish to credit Dr. H. B. Pease, at the time assistant in the Municipal Laboratory, with all that is due him for valuable services rendered.

CHART 10.—*Showing incidence of typhoid fever in Philadelphia. Black bars, for the entire city; red bars, for wards in Queen Lane district.*



taste," so that all the reservoirs below the point of pollution were more or less contaminated, though that at Queen Lane, because of the proximity of its intake, was, as subsequent events demonstrated, most affected.

Upon inquiry as to the distribution of the water from the Queen Lane Reservoir, it was ascertained, through the courtesy of Mr. J. C. Trautwine, Jr., Chief of the Bureau of Water, that the area supplied with water from this reservoir was embraced within the limits of the wards in which the largest proportion of cases of typhoid fever occurred.

The connection, therefore, between the typhoid cases in these wards and the character of water supplied to them was, in the judgment of those engaged in the investigation, reasonably established; even though repeated bacteriological examination of the water had failed to demonstrate the presence of typhoid bacilli in it.

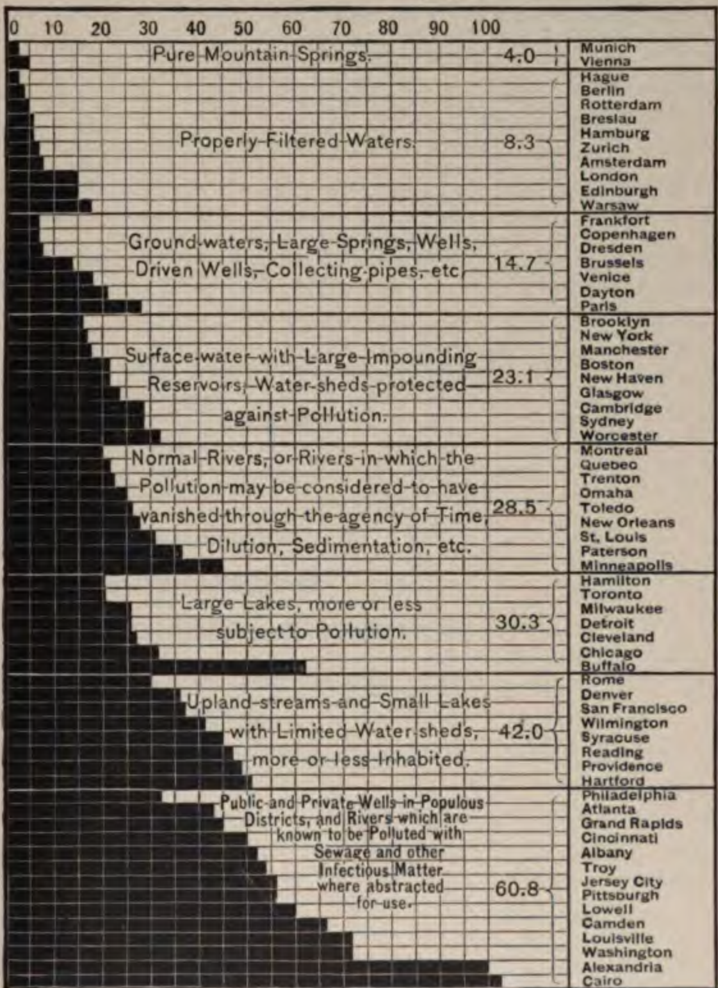
It is not necessary to discuss here the increase of typhoid fever in other sections of the city; it suffices to say that circumstantial evidence connects it also with the polluted water-supply. By reference to Chart 10 the progressive incidence of the cases, and the relation between those in the most affected district and those in the city generally, will be seen graphically represented.[1]

Chart 10 shows the typhoid morbidity in Philadelphia in the winter of 1897–98. The period represented embraces two months prior to the discharge of raw sewage into the river, and three months after the epidemic had reached its maximum. (Compiled from official reports of the Health Officer.) Black bars represent the number of cases weekly for the entire city. Red bars represent the number of cases occurring at the same time in the district supplied by the Queen Lane Reservoir into which the greatest amount of sewage was pumped. The population of this district was about one-fifth of the entire city.

To emphasize further the important relation between the

[1] For details, see *Annual Report of the Department of Public Safety of Philadelphia*, 1898; section referring to the Division of Bacteriology, etc., of the Bureau of Health.

CHART 11.—*Showing death-rates from typhoid fever in 1894 in 66 cities. Grouped according to the quality of their drinking water.*



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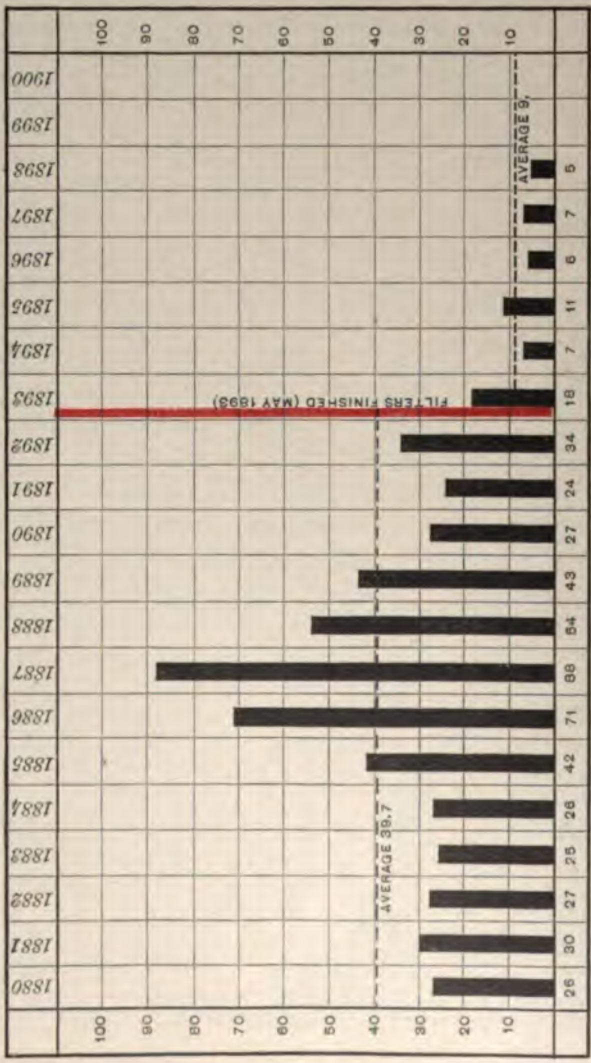


CHART 12.—*Showing the course of typhoid fever in Hamburg before and after filtration of the municipal water-supply. Deaths per 100,000 of population.*

health of communities, particularly as regards typhoid fever, and the character of water supplied to them, the accompanying chart (Chart 11) is taken from the instructive studies of Mr. James H. Fuertes. The figures at the right hand side represent the averages of the annual mortalities in each group of cities. There is no further comment needed.

Chart 12 illustrates the influence of artificial methods of purification of a polluted water-supply upon the health of the community using it. For the twelve years prior to the application of filtration to the water-supply of Hamburg, Germany, the average annual death-rate from typhoid fever was 39.7 per 100,000 of population; for the six years since filtration was established the average death-rate from the disease has been 9 per 100,000; and for the year 1898 it was 5 per 100,000. In less than one year after the water-supply of Hamburg was filtered, this city stepped from a place in the lowest to one in the second group of Mr. Fuertes' classification.[1]

ASIATIC CHOLERA.

Cause.—The disease results from the invasion of the body by the micro-organism discovered by Koch and known as *spirillum choleræ Asiaticæ*.

The spirillum, or "comma bacillus," of Asiatic cholera is, as its name implies, a curved or spiral organism, occurring most frequently as short, comma-shaped rods. It is motile, non-spore-forming, liquefies gelatin, produces indol, and does not cause fermentation of glucose or lactose. At times it coagulates milk, while again it does not. It is destroyed by an exposure of five minutes to 65° C. It is not destroyed by freezing. According to different authorities it is destroyed by drying in from three to four hours. When in a moist condi-

[1] I wish to express my obligation to Mr. F. Andreas Meyer, Chief Engineer of the city of Hamburg, for his courtesy in supplying me with the data from which Chart 12 was compiled.

tion it retains its vitality often for months, though it is probable that it becomes weakened in virulence after this time.

Its morphological and cultural peculiarities are not sufficient to lead to its absolute identification by these means alone, as there is a group of other special organisms that are in many of these respects almost identical with it. During

FIG. 6.—Spirillum of Asiatic Cholera: *I*, stained by ordinary method: *II*, stained to show flagella.

the prevalence of Asiatic cholera—*i. e.* when the disease is epidemic—the finding of spiral or comma-shaped organisms on microscopical examination of the intestinal discharges of people with diarrhea is sufficient to justify the opinion that the case is suspicious and should be considered as cholera until decided to be otherwise.

The most important diagnostic tests for this organism are its failure to infect pigeons when a small portion of a solid culture of it is introduced into the pectoral muscle, and the test with the serum of animals immunized against cholera, as devised by Pfeiffer. In this latter procedure genuine cholera spirilla when brought in contact with the serum of animals highly immunized (artificially) from Asiatic cholera lose their motility, and gradually accumulate together in small masses. (The reaction is analogous to that known as Widal's reaction for typhoid fever.) Spiral organisms that are *not* etiologi-

cally related to cholera when subjected to this test experience no change in their normal behavior.[1]

After neutralizing the acid reaction of the gastric juice and arresting intestinal peristalsis with opium, Koch succeeded in producing in guinea-pigs to which large doses of cultures of this organism were given *per os* a condition of the intestinal canal that was pathologically analogous to that seen in cholera in man.

By the ordinary methods of inoculation no effect is produced, as a rule. By injection into the peritoneal cavity of guinea-pigs the result is either that suggestive of depression due to acute intoxication, when small doses are employed, or, when large doses are used, these symptoms may be followed by death with peritonitis and evidences of general infection, though the latter is not usually conspicuous.

Geographical Distribution, Season, Race, etc.—The disease is endemic in India, where it has been known for centuries. Epidemics have occurred in practically all countries, in each instance their origin being readily traceable either directly or indirectly to the delta of the Ganges, the home of the disease. Between its first appearance in this country in 1832 and its last in 1873 there have been eight outbreaks of varying degrees of severity, those of 1832, 1853–54, and 1873 being the most severe. In all instances the origins of these epidemics were directly traceable to imported cases of the disease. Since 1873, though the disease has frequently appeared elsewhere, there have been no outbreaks of cholera in the United States.

Epidemics of the disease are much more apt to occur in the warm than the cold months, and have been known to disappear with the advent of cold weather, though this is not always the case. It is more frequent in places of low than in those of high altitude.

According to Hirsch, the negro is more susceptible to the disease than others of the human race, while the Chinese have often shown a relative insusceptibility to it.

[1] Pfeiffer: *Zeitschrift für Hygiene und Infektionskrankheiten*, Bd. xviii., S. 1; *ibid.*, Bd. xx., S. 198.

Mode of Dissemination.—Cholera is one of the *non-contagious*, infectious diseases. It is not disseminated through the air. The specific causative element is contained in the evacuations from the bowels of cholera patients, and probably *only* in the evacuations, though it is sometimes said to be present in the vomited matters.

The disease is disseminated principally through the water and through food that has become contaminated with the evacuations of cholera patients.

With regard to the epidemic occurrence of cholera, modern opinion is at one in regarding specifically polluted water as one of the most important factors in its dissemination. In the voluminous literature on the subject numerous instances are recorded in which not only was all doubt as to the part played by water in spreading the disease removed by circumstantial evidence, but in a number of cases the actual, specific, etiological factor in the malady was discovered by bacteriological methods. No more striking and instructive illustration in this connection could be cited than the cholera epidemic of Hamburg and Altona, in Germany, in the autumn and winter of 1892 and 1893. These two cities merge into one another without any definite line of demarcation. They are under distinct forms of government. Hamburg, being one of the old free cities, retains special privileges, while Altona is under the Prussian government. The population of Hamburg is about 640,400, while that of Altona is about 148,615. Both cities take their water-supply from the river Elbe. At the time of the epidemic, Hamburg distributed this water to the citizens just as it was pumped from the river, while Altona passed it through sand filters before allowing it to enter the city mains. The number of cases of cholera in Hamburg during the epidemic was 16,957 with 8605 deaths, while in Altona the cases from the same disease during the same time, numbered only 516 with 310 deaths; in other words, the number of cases of this disease in the city receiving unfiltered water was about 264.8 to every 10,000 of the population, while in the city receiving filtered water there were about 34.7 cases to every 10,000 of population; and of this number, it must be

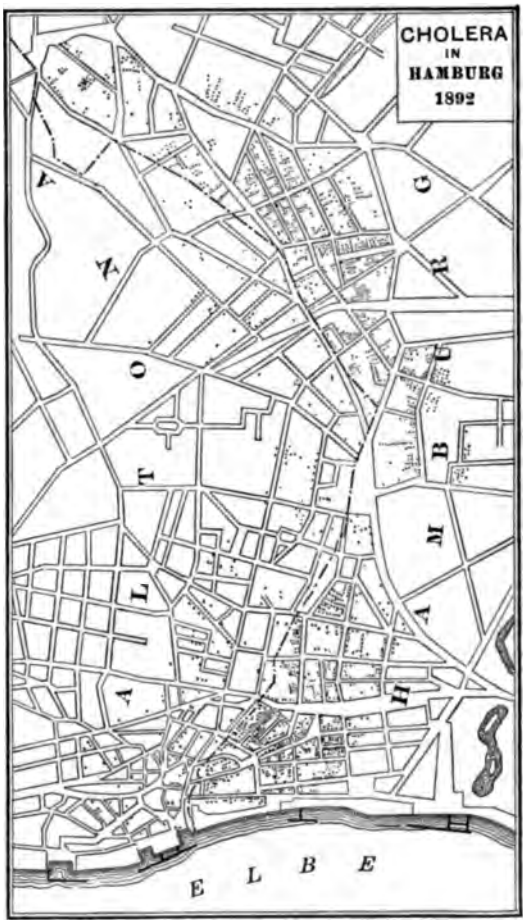


FIG. 7.—The black dots show the location and number of the cholera cases in both Hamburg (to the right of the broken dividing line) and Altona (to the left of that line).

remembered, many drank the water of Hamburg during the time of their occupation in that city, for Hamburg affords employment for many residents of Altona. Since this epidemic of 1892 one has no difficulty in determining the boundary line between Hamburg and Altona. One has but to represent graphically on a map of the two cities the locations of the cholera cases (Fig. 7) when the ramifications of the mains carrying Hamburg's impure water stand out in marked contrast to those of the Altona system carrying filtered water. Since this epidemic Hamburg has instituted a most elaborate and satisfactory system of filtration, and though there has been no opportunity to test this system against cholera, its efficiency has been demonstrated in another way. Prior to the installation of this method of purifying water the death-rate from typhoid fever in Hamburg was high, ranging from 23 to 34 per 100,000 of population; the first year after the filters were put in operation the typhoid mortality dropped to 18 and the second year to 6 per 100,000 of population (Fuertes).

The disease may be transmitted by flies and other insects that, having come in contact with the stools of these patients, convey the germs of the disease to foods, such as milk, cooked meats, fruits, etc. Experience has taught that it is carried from places in which it is endemic or epidemic, along the lines of travel and by means of surface water-courses.

All objects, articles of body- and bed-clothing, etc., that are soiled by the dejecta of cholera patients are capable of conveying the disease.

The general concomitants of poverty, such as overcrowding, filth, bad food, insufficient clothing and shelter, intemperance, and exhausting labor, especially favor its dissemination.

Portals of Infection.—The only natural mode of infection with which we are acquainted is by way of the alimentary tract. It is needless at this place to enumerate the various ways in which this may occur. It will suffice to say that, as in the case of ty[illegible] actually swallow the specific micr[illegible]ed from the bowels of

a patient sick of cholera. It is appropriate to state here that in experiments on animals with a view of reproducing the disease through the administration of the specific organism by the mouth, the acidity of the gastric juice, by destroying the organisms, has served as an effectual barrier against their growth and passage into the intestines in a living condition. To what extent similar protection is afforded to healthy human beings it is impossible to indicate, but certainly, in the light of experiment, we may look upon all conditions that tend to neutralize or diminish the acidity of the gastric juice as predisposing to infection.

Prophylaxis.—In view of the fact that in practically every instance of an outbreak of this disease, in countries in which it is not endemic, its origin has been traced to immigrants from localities where the disease is present, it is manifest that a careful system of quarantine should be established at the earliest moment after conditions become threatening. Such a system should embrace not only a suspension of the maritime intercourse, but should be uninterruptedly continued along the inland borders as well.

In addition to this, what has been said for typhoid fever, with regard to the cooking of all foods; disinfection of all excreta; disinfection by steam, hot water, or chemical means of all soiled linen, underclothing, and bed-clothing; destruction of all refuse from meals; and the scalding of all eating utensils that should be *used exclusively by the patient*, applies equally to Asiatic cholera.

In times when the disease threatens, neither water nor milk should be used that has not been previously heated to at least 70° C. for not less than fifteen minutes. All foods and drinks should be carefully protected from the access of flies and other insects, since some of these may have been in contact with the evacuations of cholera patients and thus serve as carriers of the specific agent that causes the disease.

When the disease prevails, all persons suffering from diarrhea, no matter how insignificant it may appear, should be regarded as suspicious and should be subjected to the same vigilant supervision as applies to genuine cholera patients;

for many of these cases, though mild, are nevertheless cholera, and are capable of disseminating cholera. Because of their comparatively innocent nature these mild cases often escape the attention that their importance demands; for the same reason they are more dangerous than the outspoken cases which attract attention from the onset owing to the severity of their course. Unless it be borne in mind that the mild cases, some of them not even confined to the house, are a grave menace to those with whom they are associated, and are treated as such, we can but look to them as fruitful sources for the dissemination of the disease.

Convalescents from cholera should be kept isolated, and the evacuations from the bowels should be thoroughly disinfected until bacteriological examination demonstrates that the specific micro-organism causing the disease has disappeared from the evacuations. These individuals should be permitted to mingle with others only after a disinfecting bath, and after having been supplied with clean clothing previously disinfected by steam or boiling water.

Care of the Dead.—After death a firm pledget of cotton, soaked in either 5 per cent. carbolic-acid or 1 : 1000 corrosive-sublimate solution and then wrung out, should be placed in the anus; the body should be wrapped in a sheet wrung out in either of these solutions, and it should be either buried or cremated.

The question concerning the disposal of the dead is one upon which some discussion has arisen, and as it is of no small importance, it might be of interest to see what experiment has taught us in this connection. In his experiments upon the destiny of pathogenic bacteria in the dead body, von Esmarch was unable to detect later than five days after death living cholera-spirilla in the body of a guinea-pig that had died of the experimental form of the disease; and as a result of experiments performed in the Imperial Health Bureau at Berlin, it was found that the bodies of guinea-pigs that had died of cholera, induced by Koch's method of inoculation, contained no living cholera-spirilla when exhumed after having been buried for nineteen days in wooden boxes, or for

twelve days in zinc boxes. In a few that had been buried in moist earth, without having been encased in boxes, the results of examinations for cholera-spirilla were likewise negative.

There does not seem, therefore, to be any objection to the burial of the bodies, providing the interment does not take place in a locality where a spring or water-course could be directly contaminated; indeed, on the contrary, this method of disposing of infected materials generally is second to cremation only in its requiring a longer time for the accomplishment of the same end.

AMOEBIC DYSENTERY.

(*Tropical Dysentery.*)

Cause.—Because of its constant presence in the anatomical lesions and in the stools of persons suffering from this disease; and because of the results of inoculation experiments performed by Kartulis, *amœba dysenteriæ* (also known as *amœba coli*) is now generally held to be the cause of the so-called "tropical dysentery." As its name, "amœba," implies, it is a unicellular, contractile, protoplasmic organism (Fig. 8). It has an enveloping ectosarc of clear material and an endosarc of granular protoplasm. It possesses a homogeneous, refractive nucleus, and usually several vacuoles are to be seen in its protoplasmic body. In size it ranges from 0.012 to 0.035 mm. in diameter. Kartulis has succeeded in cultivating it in hay infusions and has produced dysentery in cats by the injection of these cultures into the rectum.[1]

It may be remarked that in examining the stools of dysenteric patients for amœbæ there are certain points which, if observed, will facilitate their detection. The amœbæ are not uniformly present in all parts of the stools. They are most

[1] Kartulis: *Centralbl. für Bakteriologie und Parasitenkunde*, 1891, Bd. ix., S 365.

numerous in the small, grayish-yellow pus collections that are seen to float in the brownish fluid of the stools. They are less frequent in the viscid, blood-stained mucus. They are rare in the large greenish or yellowish-brown shreddy masses of detritus,. and when found here may often be motionless (Lafleur).

Amœbic dysentery is therefore to be considered as an infectious disease, the morbific causative agent of which is of

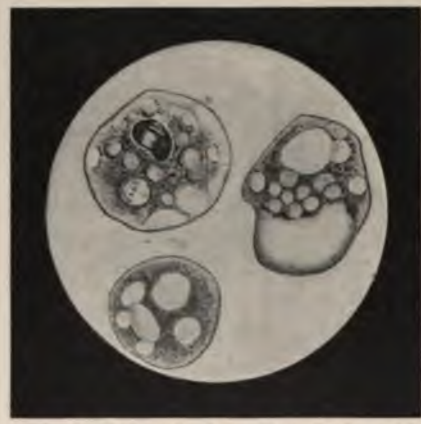


FIG. 8.—Amœba dysenteriæ (after Councilman and Lafleur).

the family of protozoa. It is not contagious in the sense in which contagion is ordinarily understood.

Geographical Distribution.—It occurs both endemically and epidemically everywhere in tropical and subtropical countries, and cases have been encountered in practically all European countries and in many parts of the United States.

Mode of Dissemination.—The amœbæ causing the disease are passed from the bowels of dysenteric patients in larger or smaller numbers, according to the severity of the attack. When abscess of the liver is secondary to the intestinal lesions, this may perforate the diaphragm, open into the lung, and the amœba may then be found in the expectoration.

We have no knowledge of the life-history of this organism

outside the body, and it is therefore impossible to speak definitely as to the means through which it may be carried from diseased to healthy persons; but if it possesses the peculiarities common to other amœbæ it is quite probable that it finds conditions in both the soil, especially marshy soils, and in water that favor its existence and development. It is not unlikely then that water and soil, when polluted with the discharge of dysenteric patients, support the life of the organism and may serve as potent factors in spreading the disease.

There are grounds for the suspicion that amœbæ capable of causing this disease are more or less constantly present in the marsh waters of many tropical places, though they have not been detected by the common methods for isolating such organisms.

Portals of Infection.—The commonest recognized portal of infection is through the mouth—*i. e.* as a result of the use of water or uncooked foods in or on which the organism is located. The experiments of Kartulis leave no doubt that infection can occur through the rectum, though this is probably a very rare mode in human beings.

Prophylaxis.—The stools of dysenteric patients should be carefully disinfected before being finally disposed of.

When the disease prevails, uncooked vegetables should not be eaten, and only water that has been boiled should be drunk.

What has been said under this head with regard to typhoid fever and Asiatic cholera applies with equal force here.

TUBERCULOSIS.

Definition and Cause.—Tuberculosis is an infectious disease characterized by the formation of nodular bodies—tubercles—from which it takes its name, and resulting from the presence in the tissues of a specific micro-organism, *bacillus tuberculosis*, discovered by Koch in 1881–82.

Opinions are somewhat at variance concerning the transmissibility of tuberculosis, particularly the pulmonary form; but the bulk of the evidence favors the opinion that the disease may be, and often has been, contracted through continuous respiration of the air of apartments occupied by tuberculous individuals. Not that the consumptive throws off with the breath, in the course of ordinary respiration, the specific bacillus of the disease, *for this is not the case*; but rather that by inattention to the proper prophylactic measures the sputum of such patients, always rich in living tubercle bacilli, is expectorated upon the floor, into napkins, or in other undesirable places, becomes dried, ground into dust, and in this form is inhaled by those in attendance upon the patient. When infection or transmission occurs, it is probably to be explained in this manner.

The bacillus of tuberculosis is a slender, rod-shaped organism usually presenting the appearance of being somewhat beaded. It is believed to form spores, it is motionless, it cannot be readily cultivated on the ordinary nutrient media, though it can be induced to lead a saprophytic form of existence on sterilized blood-serum, on nutrient agar-agar, and in bouillon to which glycerin has been added, and sometimes on potato. It develops under these conditions only at the temperature of the body. It is destroyed by the temperature of boiling water in a few minutes, and by lower temperatures also, but after a longer time—viz., in four hours by 55° C., in fifteen minutes by 65° C., in five minutes by 80° C. It is not destroyed by either drying or freezing. In the dry state it is much more resistant to heat than in the moist. It is recognized by its microchemical reaction with particular dyes.

This reaction is characterized by the tenacity with which the tubercle bacillus retains the staining, even when subjected to the action of comparatively strong decolorizing solutions. The same reaction is common to several other organisms—viz., the bacillus of leprosy, bacillus of syphilis, and the

FIG. 9.—Stained sputum containing bacillus tuberculosis. The delicate beaded rods in the figure are bacillus tuberculosis.

smegma bacillus. (For details of the method of staining and the differential tests for these organisms, the reader is referred to works on Bacteriology.)

Geographical Distribution, Race, Sex, etc.—The disease occurs in all countries, among all peoples, and at all ages. It is more frequent in overcrowded than in sparsely-settled localities, and somewhat more common in low than in high altitudes.

The American Indians and the negro races exhibit a marked susceptibility to the disease, as do also the offspring from the commingling of the white and colored races. It is seen in many of the domestic animals, notably bovines. It is tolerably common in pigs, rare in sheep, dogs, and cats. Many of the wild animals in which tuberculosis does not occur while they are in the native state develop the disease after confinement. It is of the greatest sanitary importance to note the fact that, among the domestic animals in which the

disease occurs, bovines, especially milch cows, are most often affected.

Mode of Dissemination.—As has been already stated, the part played by heredity in disseminating the disease is most conspicuously exhibited in the perpetuation of a particular condition of vitality that renders the individual endowed with it peculiarly susceptible to this form of infection.

The frequency of tuberculosis in the young of tuberculous parents cannot always be referred to the congenital existence of the disease; in fact, authorities are pretty well at one in the opinion that this is rarely the case. It is more probably due to direct infection from parent to child through their very intimate association. It cannot be denied, however, that intra-uterine tuberculosis of the fetus is occasionally encountered.

Every tuberculous individual is a source from which the disease may be further disseminated. This is conspicuously true with regard to those afflicted with the pulmonary manifestations. As said above, the sputum of consumptives contains the specific causative micro-organism—*bacillus tuberculosis*—in enormous numbers. When such sputum is allowed to dry and become ground into dust, and is inhaled as such by those in the vicinity, we see, most probably, the commonest mode of dissemination of consumption. The greater frequency of the pulmonary over other forms of the disease speaks in support of this view.

The secretions from those manifestations of the disease usually classed as "surgical tuberculosis" also contain the bacilli or their spores, and are capable of causing tuberculosis. With tuberculosis of the genito-urinary tract the bacilli are found in the urine, while from intestinal tuberculosis they are thrown off with the discharges from the bowels. From skin-tuberculosis—lupus—they escape with the secretions and with the particles of exfoliated epidermis.

An important factor in the dissemination of tuberculosis is its occurrence in certain domestic animals, especially those used as food. Though there is still a controversy with regard to the danger of infection from the use of flesh and

milk of tuberculous animals, it should be borne in mind that *bacillus tuberculosis* has been found in both, and so long as this is the case these substances must be considered as possible disseminating factors, if not rendered harmless by thorough cooking.

In addition, there are a multitude of ways in which dissemination may occur when consumptives are closely and continuously associated with healthy individuals, as in the case of man and wife, of parent and child, of patient and nurse, etc. Without detailing every possible mode of dissemination under such circumstances, it will suffice to say that the most frequent are perhaps infection through the introduction into the mouth of the specific causative organism, by the hands that have been soiled with sputum or secretions from the patient, by kissing and caressing, by using the same eating utensils and drinking from the vessels used by the patient, and by sleeping in the same bed with the diseased person.

Portals of Infection.—The commonest portals of infection in man are the lungs, the alimentary tract, and wounds of the skin. The disease may be produced experimentally in susceptible animals by subcutaneous inoculation, by interperitoneal inoculation, by direct injection into the vascular circulation, by the feeding of tuberculous materials, by the introduction of the bacilli into the air-passages, and by inoculation into the anterior chamber of the eye.

Contrary to the general rule for pathogenic bacteria, *bacillus tuberculosis* apparently has the property of forming spores, or of passing into a resistant condition analogous to that of the spore-stage, within the living body. When thrown off from the diseased body these resistant forms of the bacillus survive the unfavorable conditions that they encounter, such as drying, low temperature, scarcity or lack of nutritive material, etc., and retain the power of producing tuberculosis, when conditions favorable to the exhibition of this function again present. The investigations of Cornet demonstrate that *bacillus tuberculosis* in full possession of its pathogenic powers may often be found in the dust of rooms occu-

pied by tuberculous individuals. Some of the details of these investigations are most instructive: In 147 samples of dust collected from general hospital wards, from asylums, from prisons, from private apartments of consumptives, from surgical wards of hospitals, and from other localities occasionally visited by consumptives, *bacillus tuberculosis* was demonstrated (by inoculation into guinea-pigs) to be present 59 times—viz.:

In 38	dust samples	from	seven hospitals	it	was found	20 times
" 11	"	"	three asylums	"	"	3 "
" 5	"	"	two prisons	"	"	0 "
" 62	"	"	private apartments of consumptives	"	"	34 "
" 3	"	"	surgical wards	"	"	0 "
" 28	"	"	other localities	"	"	2 "

From this it is clear that the inhalation of dust contaminated with this organism, by individuals naturally susceptible or vitally predisposed to this variety of infection, must be a comparatively frequent channel through which the disease is contracted.

It is not my intention to open here the familiar controversy as to whether flesh and milk of bovines affected with the lymphatic or pulmonary form of the disease contain the bacillus of tuberculosis or not, but rather to call attention to the point that through the careless handling of such flesh and milk by butchers who slaughter tuberculous cattle, and by dairymen who obtain the milk from diseased cattle, both meat and milk may become accidentally infected, and if used in the uncooked state may serve as sources of infection.

Tuberculosis as a result of direct inoculation—*i.e.* through wounds of the skin—is less important to man than are the preceding modes of infection. When it does occur, the process is usually localized to the site of infection. There is reason to believe, however, that general tuberculosis may follow this mode of infection, though such a result is rare.

The localized tubercular nodule resulting from infection of

wounds of the skin, familiarly known as "post-mortem" tubercle, is encountered most frequently in those whose duties bring them in intimate contact with the morbid tissues of deceased tuberculous individuals and animals, as pathologists, butchers, workers in raw hides, etc.

Prophylaxis.—The most important prophylactic measure is thorough disinfection of the sputum and other discharges from persons suffering from the various manifestations of the disease. Cornet states that for the ten years ending with 1897 the death-rate from consumption in Germany was 21.5 per 10,000 against 31.4 for a corresponding previous period. He believes the result due to more general efforts at the suppression of indiscriminate spitting and more care in preventing tuberculous sputum from becoming dried and disseminated through the air as dust.

The patient should be impressed with the fact that he is a possible source of infection, and that it is quite within his power to control the spread of the disease from himself by attention to a few simple details that will in no way interfere with his comfort.

If he be suffering from pulmonary consumption, the sputum should be spat into covered vessels containing a disinfectant fluid, or into a vessel containing plain water, which is subsequently to be boiled. Cheap paper sputum-cups that can be burned after use are now to be had of all druggists. The cups to receive the sputum, other than those of paper that are to be burned, should be of china or enamelled ware, and should be thoroughly scalded with *boiling* water at least twice daily. When the patient is away from his apartments and cannot use the sputum-cup, he should be provided with cheap handkerchiefs or napkins, into which he should expectorate, which should be burned after using. A very good form of handkerchief for this purpose is the paper "Japanese handkerchief."

Bed-clothing or night-clothing soiled with tuberculous sputum should be at once removed and scalded. The consumptive should be provided with his own eating utensils, napkins, etc., and these should be used by him alone, and

should be scalded immediately after use. The refuse from his meals should also be scalded; never used by others.

The living- and the bed-room of the patient should be kept scrupulously clean, and should be frequently aired. Under no circumstances should spitting about the room be permitted. "Dusting" should not be practised, but when necessary all objects should be wiped with a cloth moistened in 1 : 1000 corrosive-sublimate or 3 per cent. carbolic-acid solution. The importance of this precaution is conspicuously illustrated in Cornet's investigations, cited above, by the marked difference between the dusts from medical wards of hospitals, where there is more or less of laxity concerning the importance of cleanliness as a factor in asepsis, and the dusts from surgical wards, where this point is kept constantly in mind. Kissing, caressing, shaking hands, and other modes of intimate association should not be indulged in by the consumptive. The hands should be thoroughly washed after manipulating tuberculous patients.

By thorough cooking tuberculous meat and milk are rendered free from danger. The slaughter of animals for public consumption should be under authorized inspection and control, and the entire carcasses of animals found to be tuberculous should be discarded and burned or buried. Similarly, dairy herds should be periodically inspected by qualified veterinarians, and the sale of milk from all suspicious animals should be prohibited. Tuberculous individuals should not be engaged about dairies. In recommending that the marriage of consumptives should be discouraged, the writer appreciates the almost total impracticability of the suggestion; but it is nevertheless the duty of the physician to discourage such unions whenever the opportunity presents for him to do so.

ACUTE CROUPOUS PNEUMONIA.

(*Lobar Pneumonia.*)

Definition, Cause, etc.—An acute, specific inflammation of the lungs due, in the vast majority of cases, to the presence in the diseased area of *micrococcus lanceolatus* (pneumococcus). In a very small proportion of instances pneumonia, with all its anatomical and clinical characteristics, has been observed to follow the invasion of other species of bacteria—viz., *streptococcus pyogenes*, pneumobacillus of Friedländer, and *streptococci* and *staphylococci pyogenes* together. In this disease the part played by a predisposing cause appears to be eminently essential to infection. While manifestly infectious, there is some room to doubt that the disease is contagious in the strict sense of the word, though numerous local outbreaks (house-epidemics, prison-epidemics, barrack-epidemics, etc.) have been recorded.

Micrococcus lanceolatus, also known as *diplococcus pneumoniæ*, pneumococcus of Fränkel, *streptococcus lanceolatus Pasteuri*, *Micrococcus pneumoniæ crouposæ*, *diplococcus lanceolatus capsulatus*, micrococcus of sputum-septicemia, and meningococcus, is, as its name implies, a lancet-shaped micrococcus, usually found in pairs, though occasionally in short chains. When in pairs the broad ends of the lancet-shaped cells are in juxtaposition. When examined directly from the diseased lung, as in the rusty sputum of patients, it is found, by appropriate methods of staining, to be enveloped by a delicate capsule (Fig. 10), though under artificial cultivation the capsule is rarely observed.

Micrococcus lanceolatus is not conspicuous for its saprophytic tendencies; it is difficult to cultivate, and at times loses its vitality, after three or four generations, under artificial circumstances. Under these conditions it often becomes rapidly diminished in virulence, though this is not always the case. It is constantly present in the mouth-cavity of from 15 to 20 per cent. of healthy individuals; by some it is thought to be present in the mouth of every one at one time or another, and it is found in the sputum of practically all persons

suffering from croupous pneumonia. It is demonstrated to be the cause of a number of other pathological conditions—viz., meningitis, acute ulcerative endocarditis, pericarditis, otitis media, acute circumscribed abscess, and pleuritis. It is an organism of very low resisting powers, and is readily

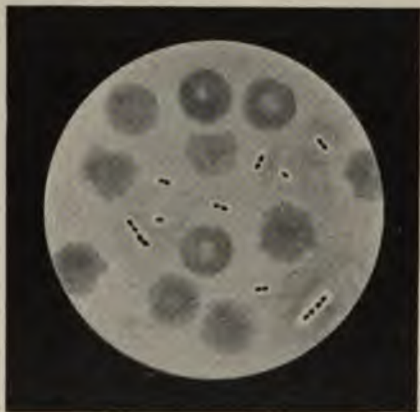


FIG. 10.—Micrococcus lanceolatus (pneumococcus) in blood.

destroyed by either thermal or chemical methods of disinfection.

It does not grow at a temperature lower than 25° C., nor above 42° C. The temperature most favorable to its growth is that of the body—viz., about 37° C. Its thermal death-point is 52° C. in ten minutes (Sternberg).

It is very pathogenic for white mice and rabbits, less so for guinea-pigs. Subcutaneous inoculation of these animals with this organism does not result in the production of pneumonia, but instead, the animals succumb to a rapidly-fatal form of septicemia. Pneumonia may, however, be produced in a fair proportion of cases by the injection of either cultures of this organism, or the juices from a pneumonic lung directly into the lung-substance through the wall of the thorax.

Geographical Distribution, Age, Sex, etc.—Pneumonia does not appear to be more frequent in one country than in another. It occurs in both hot and cold climates. It is most frequent in this latitude during January, February,

and March. It attacks all ages—men more frequently than women, and the aged more often than the young.

Modes of Dissemination.—Though, as stated, *micrococcus lanceolatus* usually loses its pathogenic properties in a short time after having been cultivated under artificial circumstances, it is nevertheless observed to retain its virulence for a comparatively long time in sputum, blood, and other pathological exudates. Even when dried under these conditions, it has been found to be virulent for as long as fifty-five days. It is not unlikely, therefore, that dried pneumonic sputum may, when ground into dust, serve as a means for the dissemination of pneumonia, just as dried tubercular sputum is believed to be an important factor in spreading tuberculosis.

When a number of cases occur simultaneously or in rapid succession in isolated localities, the outbreak beginning with almost explosive violence, as is sometimes the case, it is reasonable to assume a common depressing influence that predisposes numbers of persons to infection from some common source; these individuals then in turn serve as sources for the further spread of the disease. As the pneumonic patient is the source from which the most highly pathogenic varieties of the causative organisms are obtained, it is clear that an individual predisposed by one debilitating influence or another, when intimately associated with the patient, would present conditions eminently favorable to direct infection. The fact that the disease is not commonly regarded as transmissible explains the indifference on the part of many to precautions against infection, and it is probably through such laxity that the disease is at times contracted.

Furthermore, predisposing influences may so reduce the normal resistance of the individual as to favor auto-infection from his own mouth or nose-cavity by *micrococcus lanceolatus* that had hitherto existed there as a harmless commensal species. Pneumonia is especially apt to follow upon exposure to sudden and extreme variations in temperature, upon exposure to excess of cold and moisture, and upon

the debilitating effects of exhaustion, alcoholism, traumatism, and diseases of other kinds.

Portals of Infection.—Our knowledge of the subject does not permit of a definite statement as to the relative frequency of infection from extraneous sources and auto-infection from the mouth, or from other primary foci of disease in the body. Nevertheless, there is every reason to believe that, whatever the source of infection may be, the disease results, in the vast majority of cases, from the deposition of the morbific agent in the tissues of the lungs, from either the mouth or nasal cavities, directly or by way of the lymphatic or vascular circulation.

While much less frequent, it is still probable that pneumonia sometimes arises as a phenomenon secondary to a primary site of pneumococcus infection in the body, the causative agents being carried from the diseased area to the lungs by the circulating fluids or wandering cells.

Prophylaxis.—The most important prophylactic measures are those directed to the maintenance of the general tone of the body—*i. e.* those that tend to support the normal vital resistance of the tissues; for, as stated above, this particular variety of infection is conspicuously favored by all those predisposing causes of disease that tend to depress the general vitality.

Careful attention should be paid to the hygiene of the person, including regular meals of nutritious food, protection by proper clothing from the influence of sudden and extreme changes of temperature and of excessive cold and moisture, rational exercise in the fresh air, and frequent bathing. The excessive use of alcohol is generally regarded as a conspicuous factor in predisposing to pneumonia.

Those who are in attendance on pneumonia patients should remember that the sputum of such patients contains the living morbific agents, and that it retains its power of infecting even after being dried. The sputum should therefore be received in covered cups containing fluid; these should be scalded with boiling water three or four times daily. Should the hands become soiled with the sputum they should at once

be washed with soap and water, and should always be thoroughly washed before meals. Attendants should refrain from unnecessary, intimate contact with the patient. Eating-utensils, refuse of food, soiled clothing, etc., should be scalded as soon as removed from the ward or sick-room.

The sick-room should be kept thoroughly clean, should be well aired without draughts, and should be properly lighted.

Attendants, often exhausted by their prolonged duties with the patient, should observe carefully the directions given above, and should bear in mind that they especially, owing to the frequency of their lowered physical condition and to their constant association with the patient, offer conditions most favorable to infection. They should be particularly attentive to their personal hygiene, and should endeavor to spend a part of each day in the open air.

DIPHTHERIA.

Cause.—Diphtheria results from the pathogenic activity of *bacillus diphtheriæ*, discovered microscopically by Klebs, and subsequently isolated in pure culture and proved by Löffler to stand in causal relation to the disease. This organism is therefore also known as the Klebs-Löffler bacillus of diphtheria.

Diphtheria is an infectious disease which is also generally regarded as contagious.

Bacillus diphtheriæ is a non-motile, non-liquefying, non-spore-bearing rod that is conspicuous for the irregularity of its morphology. It may be recognized in microscopical preparations, from either diseased area or from cultures, by the following peculiarities: It occurs as irregularly stained rods with one or both ends swollen; as rods broken at intervals into short, sharply-defined segments of either a round or an oval shape; as longer rods markedly clubbed

at one or both ends, and as short oval or lozenge-shaped bodies. In some preparations one or another of these forms will predominate; in others they may all be observed together. As a rule, they stain irregularly. Occasionally they take on the dye with a moderate degree of regularity. Often sharply defined, very deeply stained round or oval points will be seen in the individual cells. It stains with the ordinary basic anilin dyes. It grows readily on most of the ordinary nutrient culture-media, especially those of a feebly alkaline reaction that can be kept at the body-temperature. It is not

FIG. 11.—Showing three morphological variations of bacillus diphtheriæ: *I*, as seen on glycerin agar-agar; *II*, as ordinarily seen on neutral or slightly alkaline Löffler's blood-serum mixture; *III*, as seen on slightly *acid* blood-serum mixture.

readily destroyed by drying, and under these circumstances has been known to retain its vitality for from ten to fourteen weeks. It is readily destroyed by both thermal and chemical means. Its thermal death-point is 58° C. in ten minutes. It is destroyed in cultures by the direct action of sunlight in from thirty to forty-five minutes. It is highly pathogenic for guinea-pigs and kittens; much less so for other animals used for experiment. By subcutaneous inoculation in guinea-pigs there is produced a local condition that is in many ways analogous histologically to that seen locally in the throat of human beings. By introduction into the trachea of kittens a

pseudomembranous exudate may be produced that is in all respects similar to that occurring in man.

In human diphtheria, and in the experimental form, the specific micro-organism is usually found *only* at the local site of disease. By special methods they may often be detected at more remote parts of the body, but in only very small numbers. When present in the internal organs they do not, apparently, play any part in the general process. The disease does not result, therefore, from the general invasion of the body by the causative micro-organism, but from the dissemination of soluble poisons elaborated by it at the local site of disease to which its activities are confined. It is to the action of these poisons that the constitutional symptoms, the secondary or concomitant manifestations, and the remote degenerative processes of organs, commonly seen in diphtheria, are due.

Geographical Distribution, Season, Age, etc.—The disease has been known since the time of Galen. It has been observed in practically all countries. It received its name and was first definitely described and identified as a distinct affection by Bretonneau, of Tours, in 1826, though in 1771 a pamphlet, entitled *An Inquiry into the Nature, Cause, and Cure of the Angina Suffocation, etc.*, was published by Samuel Bard, of New York, in which was given a description of the clinical and anatomical manifestations of diphtheria that was quite comparable in its wealth of essential details to that subsequently given by Bretonneau.

The disease is more common in cold and temperate than in hot climates. It prevails much more extensively during the autumn and early winter than at other seasons. It is endemic in cities; it frequently appears in an unusually severe epidemic form in country districts. It occurs at all ages, but the greatest number of cases fall between the third and fifteenth years of life.

Modes of Dissemination.—Though contagious, it is nevertheless probable that the disease is rarely contracted by simply breathing the air of rooms occupied by diphtheritic patients, for the reason that the specific micro-organism is

not contained in the breath of the patient, and is not eliminated in this way in the course of ordinary quiet respiration. It is, however, dislodged during coughing, sneezing, gagging, etc., along with minute particles of false membrane from the fauces. Nurses and physicians are especially liable to have bits of membrane coughed into their faces during the usual manipulations about the throat of the patient. It is accidents of this kind that make the duties of attendants on diphtheria patients particularly dangerous, and it is among such attendants that instances of direct infection occurring in this way are frequently observed. It is also to be noted that the bacillus of diphtheria is not readily destroyed by drying, and that when dislodged from the throat in bits of false membrane it may retain its vitality for a long time. When such particles of dried membrane are disintegrated, dissemination may occur through the breathing of air laden with this infective dust. Similarly, napkins, clothes, towels, handkerchiefs, bed- and night-clothing, on which saliva from the patient has been allowed to dry, may serve in this way to spread infection. Wright and Emerson detected living diphtheria bacilli in the hair and on the shoes of nurses, and in a broom in the diphtheria ward of the Boston City Hospital.

Through inattention to the hands, soiled while manipulating the patient, the disease may readily be disseminated. In short, all modes of immediate contact with the diseased person offer opportunities for infection. There is a pretty widespread belief that domestic animals are instrumental in spreading the disease. This opinion is based on the fact that certain animals, notably calves, cats, and chickens, suffer from a pseudomembranous inflammation of the mucous membrane of the upper air-passages that has been taken to be diphtheria. This view is usually erroneous. Those affections common to animals, that simulate diphtheria in man, are etiologically totally distinct from human diphtheria, and genuine diphtheria cannot be contracted from animals affected with those diseases. It must be said, however, that cats are reported to have suffered from diphtheria contracted from human beings.

A number of epidemic outbreaks of the disease have been traced to the milk-supply of those affected. This has given rise to the supposition that one or more of the cattle from which the milk was obtained were diphtheritic. There is no trustworthy evidence that cattle ever suffer spontaneously from a disease capable of transmitting diphtheria to man. When "milk-epidemics" of diphtheria do occur, they are probably in all cases due to contamination of the milk with the genuine diphtheritic virus from human sources—*i. e.* from the family of the dairyman, or from some of the others through whose hands it passes before reaching the consumers.

There is no evidence to support the opinion that the disease is disseminated by the water. Neither is there any evidence, though opinion in abundance, that the disease is spread by the air of drains and sewers. Where, through defective plumbing, there is a direct passage for the infective materials thrown into closets and sinks, through leaks in the soil-pipes, it is manifest that the disease may be spread by such materials finding their way into other parts of the building and not into the sewers, as intended. Barring such a condition as this, it is difficult to conceive the way in which the air from sewers may play a part in disseminating diphtheria, or in fact any other variety of infection. All statistics show us that those constantly engaged about sewers, and on sewage farms, are not more liable to infective diseases than are those following other occupations. The air of sewers is poorer in micro-organisms of all kinds than is that of the overlying streets; the chemical composition of the air of sewers is not such as to warrant the opinion that it is irritating and when breathed predisposes the respiratory mucous membranes to infection by its irritating qualities; moreover, when leaking into a room it becomes so diluted by the air in the room as hardly, if appreciably, to alter the chemical composition of that air.

Portals of Infection.—For faucial diphtheria the portals of infection are the nose or mouth. Diphtheritic inflammations, etiologically identical with diphtheria, are occasion-

ally observed in other localities—viz., on other exposed mucous surfaces, as conjunctiva, vagina, etc., and upon wounds of the skin that have become infected with the specific diphtheria virus. During the course of the disease in the fauces, auto-infection of wounds on exposed surfaces of the body is not rare.

Infection of the nasal mucous membrane often results in a more or less chronic process, known as membranous or fibrinous rhinitis, though the acute manifestation of the disease is likewise observed in this locality.

Prophylaxis.—The most modern, and certainly the most important, prophylactic measure is that through which a condition of immunity from the disease is afforded by the subcutaneous injection of the blood-serum from an animal that has been artificially rendered highly immune from the poison of diphtheria. As the immunity thus induced is not permanent, lasting for but a few weeks at most, this procedure is only employed when healthy persons are directly exposed to the disease, especially as in the case of the well children of a family in which the disease is present.

As the site of infection is the local area of diphtheritic inflammation, it is plain that all objects in any way contaminated with matters from this area are infective, and should be scalded as soon as removed from the patient. These patients should be provided with separate eating utensils, which should be scalded after each meal. The refuse from meals should be scalded with *boiling* water. Soiled bed- and body-clothing should be scalded before the secretions are permitted to dry upon them; or, where this is not practicable, the soiled areas should be moistened with 3 per cent. carbolic-acid or 1 : 1000 corrosive-sublimate solution.

Nurses and physicians should guard against infection by thoroughly washing and disinfecting the hands immediately after manipulating the patient. While spraying or otherwise attending to or examining the throat, a cotton mask, moistened with either of the above-named solutions, should be worn; this to guard against infection that might otherwise result

from bits of membrane being coughed into the mouth, nose, or face.

These patients, where possible, should occupy a room in an unfrequented part of the house, and should be isolated, in the full sense of the word, as completely as possible; that is to say, only those in immediate attendance should have access to the room, and *all articles* that have been about the patient should be scalded or otherwise disinfected before they leave the sick-chamber.

From the standpoint of prophylaxis it is important to note that the diphtheria bacilli do not, as a rule, disappear from the throat with the disappearance of the false membrane, but often persist far into the period of convalescence. In the experience of the Laboratory of the Board of Health of Philadelphia it is found that the average period of persistency of diphtheria bacilli in the throats of convalescents from this disease is twenty-nine days, reckoned from the date of establishment of the diagnosis by the primary bacteriological examination. In one case they were present after one hundred and twelve days, while in a very few cases they disappeared as early as the seventh day after their first detection.

Because of the persistence of the infective agent in the throat of these patients, convalescents from diphtheria are now regarded as dangerous sources of infection until they are shown to be otherwise by bacteriological examination of the throat—*i. e.* until such examinations demonstrate the disappearance of the bacilli.

NOTE.—Processes of disinfection are given in the Section devoted to that subject.

EPIDEMIC CEREBROSPINAL MENINGITIS (CEREBROSPINAL FEVER; SPOTTED FEVER).

Definition, Cause, etc.—An acute infectious disease, the clinical manifestations of which are referable to a seropurulent inflammation of the meninges of the brain and spinal cord.

Though sporadic cases are occasionally encountered, the tendency of the disease is to appear simultaneously among a number of the individuals of a community.

The cause of the disease is now generally regarded as the micrococcus described by Weichselbaum in 1887 under the name of *diplococcus intracellularis meningitidis.* As its name implies, this organism is found usually in pairs, the surfaces in juxtaposition being flattened, and usually located within the bodies of the pus-cells of the exudate in very much the same way that the gonococcus is located in the pus-cells of gonorrhea (see Fig. 16). It can readily be detected in the cerebrospinal exudates in genuine cases of this disease by microscopical examinations of cover-slip preparations. Its detection in this way in the spinal exudate obtained by lumbar puncture during the early stages of the disease places the diagnosis beyond doubt.

This organism can be cultivated, but with difficulty. The media most favorable to its cultivation are the solidified blood-serum mixture of Löffler and nutrient agar-agar, though occasionally it will not develop on either, even though it may have been easily detected in the exudate on microscopical examination. It grows only at body-temperature. It is decolorized when treated by the method of Gram. It stains with the ordinary anilin dyes. Councilman, Mallory, and Wright found that cultures of it lost their vitality in eight days; that when dried it died in from twenty-four to seventy-two hours, according to circumstances; that it was killed in from four to seven hours by exposure to mixtures of formaldehyd gas and air in proportions of from 1 : 7500 to 1 : 225,000; and that a solution of 1 : 800 carbolic acid prevents growth.

The results of the injection of either the exudate or of cultures from it into animals in the ordinary ways are uncertain. Heubner, and Councilman, Mallory, and Wright succeeded in producing the typical pathological lesions of the disease by direct injections into the subarachnoidal space of the goat. Heubner's animal died in thirty-six hours, while that of the Boston investigators lived for only seventeen or eighteen hours; both of which experiences testify to the very great virulence of the materials employed by them.

It must be borne in mind that *epidemic* cerebrospinal meningitis should not be confused with the other forms of meningitis from which it is etiologically distinct. Sporadic cases of cerebrospinal meningitis are from time to time encountered, the etiological factors of which are not the same in all instances. Typical cerebrospinal meningitis may be caused by *streptococcus pyogenes*, by *micrococcus lanceolatus* (pneumococcus), and by *bacillus tuberculosis*, though tubercular meningitis has certain anatomical points of distinction that readily aid in its identification. These types of meningeal infection, unlike *epidemic* cerebrospinal meningitis, show no tendency to occur in the form of widespread outbreaks, but, as stated, are encountered only as sporadic cases.

History, Distribution, etc.—The first authentic account of this disease as it is to-day recognized is that given by Vieusseaux of the epidemic in Geneva in 1805; though there can be no doubt that the disease had appeared elsewhere prior to that date. Since then epidemics of varying degree have been described in almost every part of the civilized world. The year after the description of the disease by Vieusseaux, Danielson and Mann first called attention to its occurrence in this country. After its primary appearance in Massachusetts in 1806 it continued throughout New England in various localities for the subsequent ten years. In his elaborate article Hirsch distributes the epidemic occurrence of this disease through four periods, namely 1805–1830; 1837–1850; 1854–1875; 1876 to date. In the first period it appeared in isolated epidemics in Europe and to a much greater extent in the United States; in the second period

widespread epidemics occurred in France, Italy, Algeria, the United States, and Denmark; during the third period it included Europe, Asia, Africa, South America, and the United States; while in the last period it has been especially marked in Germany, Italy, and the United States. In commenting further upon this disease Hirsch expresses the opinion that it is becoming more and more circumscribed in its occurrence and that it can hardly be longer regarded as an endemic disease of the people.

A singular feature of the disease is its comparative lack of extension by continuity. Its appearance in a community is usually characterized more by its simultaneous occurrence in a number of individuals, not necessarily closely associated, than by its gradual extension from one person to another. It is also common for the disease to manifest itself in widely scattered localities; thus, for instance, in 1857 it appeared simultaneously in North Carolina and in western New York. It is manifest that the peculiar distribution and occurrence of the epidemics in no wise tend to simplify the study of all the factors concerned in their causation, dissemination, etc.

Its outbreak at some time and place may comprise but a few scattered cases, while at another place, but simultaneously, large numbers may be affected. At one period it may be comparatively mild, at another alarmingly severe. It may reappear as a widespread epidemic of a very virulent type in localities in which it had appeared previously in only an insignificant way. It may appear in several occupants of the same house, or in persons who have temporarily resided in the same house with one sick of the disease, giving rise to the opinion that it is transmitted by contagion. On the other hand, single cases often occur in a family, the members of which are intimately associated with one another, and all others may escape. It has appeared in a house, disappeared for a time, and reappeared.

Age, Social Condition, Season, Mortality, etc.—Epidemic cerebrospinal meningitis is a disease of childhood and early adult life. It is rare before one year, and gradually diminishes in frequency after thirty years of age. Though

the concomitants of poverty usually seem to predispose to the disease, there is abundant evidence to demonstrate that these conditions are not essential to its causation. In the recent epidemic in Boston, for instance, the cases, with the exception of a limited area along the water-front, were pretty evenly distributed throughout both the poorer and better parts of the city.

It is a disease of late winter and early spring. It has been known to disappear with the onset of warm weather; it has been known to make its appearance in warm weather. Prolonged rain is thought by some to favor it. Excessive cold is thought by others to favor it. Available evidence does not justify the opinion that atmospheric conditions *per se* have or have not anything to do with its advent.

The mortality varies according to the severity of the epidemic from 25 to 70 per cent. of all affected. In the Boston outbreak of 1896–1897, 68.5 per cent. of the 111 cases seen in three hospitals proved fatal. Rollet, in presenting the statistics on this point for all epidemics in France up to the year 1884, records seven in which the mortality was less than 50 per cent., and nine in which it was above 50 per cent.; in the former group the lowest mortality was 28 per cent., in the latter the highest was 75 per cent.

Hirsch states that the disease is more common among negroes than whites, but he is inclined to regard this as due less to racial peculiarity than to social conditions.

It is a disease of subtropical and temperate climates, and is, according to Hirsch, unknown in the tropics and rare in colder regions.

Portals of Infection, Modes of Dissemination, etc. —When we remember that the essential lesion of the disease is enclosed within bony cavities and that it is usually confined to the tissues in these cavities, it is evidently difficult to offer any satisfactory opinion as to the channels through which primary infection took place, or those through which the specific micro-organism may be eliminated from the diseased person, both points being requisite to an accu-

rate understanding of the phases of the subject under consideration.

There can be no doubt that infection occurs from without; that the infective matters are carried to the meninges through either blood or lymphatic channels or both; but whether it enters the body through the alimentary or respiratory tracts or through superficial wounds it is not possible to say.

In severe epidemics fatal results occur so quickly after the onset of the disease that in many cases there is no involvement of other organs than those within the cranium and spinal canal, and the specific micro-organism is confined to these localities. It is hardly conceivable, therefore, that these cases serve as sources from which attendants or other individuals in association with the sick may contract the disease. In a certain proportion of cases there is secondary involvement of other organs that communicate more freely with the surface of the body—*i. e.* secondary pneumonia, middle-ear inflammations, and involvement of special organs and of mucous and serous surfaces may be encountered. If the disease is really transmissible from person to person, it is probably this group of cases that is most favorable to it. It must be said, however, that the bulk of evidence does not lead to the opinion that epidemic cerebrospinal meningitis is a directly contagious disease, or that it is often carried from the sick to the well by fomites. The history of numerous outbreaks leads more to the opinion that the cases are infected from some common source, and that they are predisposed to such infection by some unusual local condition. This opinion is supported by the peculiarity of the epidemic outbreak of this disease as noted above—namely, that it shows no special tendency to progress along continuous lines or through contiguous localities. It may appear suddenly in a locality, and as suddenly disappear to reappear almost at once in some remote district. It has been known to appear in two regiments in camp, while a third, located between the infected regiments, escaped. Love states that at New Orleans in 1847, the disease attacked one regiment which was quartered in poor barracks on damp soil, and supplied with poor

clothing, while an adjacent regiment, more favorably housed and clothed, escaped entirely. The history of the disease is characterized throughout by irregularities in the manner of its occurrence and the conditions under which it has made its appearance. At times it has prevailed in rural districts, the cities remaining comparatively free, while again the reverse has been the case.

Prophylaxis.—From what has been said, it is manifestly impossible to outline a rational scheme of prophylaxis against this disease. We lack what underlies all such systems—namely, precise knowledge of the manner of infection and the channels of dissemination of this malady.

Since it is improbable that the disease is transmissible from person to person, rigid isolation of the sick is not generally regarded as imperative. In the protracted cases, especially those with secondary involvements, the discharges and excreta should be disinfected as soon as passed. The dead should be disposed of by burial or cremation as soon after death as decency and circumstances will permit.

Since the evidence leads us to regard the occurrence of the disease as favored frequently by local predisposing conditions, such as bad hygienic environment in general, too much care cannot be given to the sanitation of the house, personal hygiene, and those measures that prevent infection by way of food and drink.[1]

[1] Read Hirsch : *Pathologische Geographie*, Bd. iii., S. 379 ; Councilman, Mallory, and Wright : *Epidemic Cerebrospinal Meningitis and its Relation to other Forms of Meningitis ;* a Report of the State Board of Health, Mass., 1898 ; Stillé : *System of Medicine*, vol. i., 1885.

INFLUENZA.

Cause.—Influenza is an infectious catarrhal process in which the causative micro-organism, probably *bacillus influenzæ*, is localized in the respiratory tract. The accompanying constitutional manifestations are apparently of toxic origin, resulting from the absorption by the blood of toxins produced by the growing bacilli in bronchial mucous membranes. The bacillus of influenza is a very small, non-motile, non-spore-bearing, non-liquefying rod that is constantly to be found in the sputum of individuals suffering from influenza. It stains less readily with the ordinary basic anilin dyes than

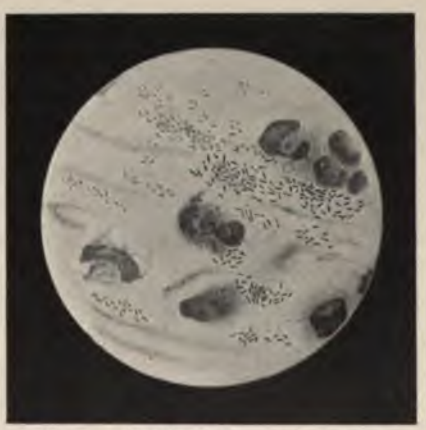


FIG. 12.—Bacillus influenzæ in sputum.

do other bacteria. It does not stain by Gram's method. It may be isolated in pure culture from the sputum of influenza patients. It cannot be readily cultivated on the ordinary nutrient media. It grows only at body-temperature and upon the surface of media over which has been distributed either blood or blood-coloring matter. The coloring matter of the blood appears to afford substances especially adapted to the nutrition of this organism. Its colonies appear as very minute, discrete, colorless points of growth that have somewhat the appearance of small drops of dew.

It is extremely sensitive to drying, withstanding the process at 20° C. for but little over twenty-four hours.

The results of inoculation of animals with cultures of this organism indicate that under these circumstances its pathogenesis depends more upon toxic than upon actively infective properties.

Occurrence, Distribution, etc. — Influenza appears usually in an epidemic form, having its origin in some one locality or another and travelling with great rapidity, often as a true pandemic, over the major part of the inhabited earth's surface.

According to Hirsch, the first trustworthy literary records of the disease date from the early part of the twelfth century. Between 1173 and 1874 it made its appearance on eighty-six different occasions. Its first recorded occurrence in the United States was in Massachusetts in the summer of 1627; since that time it has visited this country with varying degrees of severity twenty-two times. The last pandemic, that of 1889–1890, appears to have originated in Central Asia and to have spread thence to Russia, Germany, France, England, and finally to North America. Its occurrence does not seem to be influenced by climate, season, geological or geographical conditions. The ideas regarding the periodicity of its visitations, and that relating to the fixity of the direction of its spread from east to west, receive no support from Hirsch's analysis of the various epidemics. Neither race, sex, nor age appears to serve as an important predisposing factor.

Dissemination.—It is impossible to say what the conditions are that favor its development and spread. Its dissemination over large areas is often so rapid as hardly to admit of the explanation that it is carried from place to place by travellers or through merchandise. The fact that the organism which is believed to be its cause is quickly destroyed by drying contraindicates in a measure the opinion that the virus is transported from one locality to another by winds. Undoubtedly the spread of the disease is, in part at least, accomplished through infected travellers. Our knowledge is

not sufficient to allow of the statement that it is directly transmissible from individual to individual, but a great deal of circumstantial evidence points to this as being the case.

Mode of Infection.—On this point also our information is but meagre, and it can only be said that in all likelihood infection occurs through the respiratory tract.

Prophylaxis should consist in careful attention to the hygiene of the person, the avoidance of all influences that tend to lower the general tone of the tissues and, in so far as is possible, non-communication with individuals already affected with the disease. The invasion of the malady is usually so subtle that prophylactic measures are of but little avail.

The handkerchiefs, napkins, eating utensils, and the sputum of influenza patients should be scalded before they are taken from the sick-room.

When we remember how great a number of cases in any epidemic of this disease are not confined to the house, it is manifest that elaborate prophylactic measures can be operative against only a part of those sick. The walking cases cannot be brought under control; these may be and probably are the most important disseminators of the infective materials.

BUBONIC PLAGUE.

Definition, Cause, etc.—An acute, specific, contagious (?) disease that is characterized by inflammation, and in many cases by suppuration of the lymphatic glands, especially those of the inguinal, axillary, cervical, and submaxillary regions. It is attended with great mortality. According to Yersin, the death-rate among hospital cases during the late epidemic in China was about 95 per cent. The investigations of Yersin and of Kitasato point to a specific micro-organism as the exciting cause, while all writers are at one in the

opinion that the most predisposing causes are the common concomitants of extreme poverty—namely, overcrowding, filth, bad air, poor food, and intemperance.

The organism discovered by Yersin and by Kitasato in cases of the disease examined by them during the epidemic at Hong Kong in 1894, is described as a short, oval, capsulated, actively motile, non-spore-bearing, polar-staining

FIG. 13.—Pus from bubo in bubonic plague; showing the specific micro-organism.

bacillus. It is present in large numbers in the suppurating glands, and in smaller numbers in the blood.

It stains with the ordinary anilin dyes, taking up the color more intensely at its ends than at its middle portion. It is decolorized by Gram's method of staining.

It grows luxuriantly, without liquefaction, on solidified blood-serum, as a yellowish-gray deposit. It may also be isolated on agar-agar, especially when glycerin has been added. It does not cause uniform clouding of the bouillon, but grows in shred-like clumps that adhere to the sides or sink to the bottom of the tube. The temperature most favorable to its growth is between 36° and 39° C.

It is destroyed in four days by drying at the ordinary temperature of the room. Direct sunlight kills it in from three to four hours. It is killed in a few minutes by steam at

100° C., and in half an hour by 80° C. It is destroyed by an exposure of two hours to carbolic acid, in 0.5 per cent. solution, and to milk of lime in 1 per cent. solution.

Rabbits, guinea-pigs, rats, mice, and sheep are susceptible to subcutaneous inoculation with the plague bacillus. Pigeons are immune. The lesions found at autopsy in animals dead after inoculation, either with cultures of this organism or with pus from a suppurating gland, while not apparently identical with those seen in the human cadaver, do nevertheless present certain features that may be considered as in part a reproduction of the disease—namely, the marked involvement of the lymphatic apparatus. The organism is found in the internal organs of animals dead from inoculation.

Distribution, Race, Season.—Our knowledge of this historic pestilence dates from about the end of the first century of the Christian era. Its home was for centuries supposed to be Northern Africa. During, and for a period after, the Middle Ages, it was more or less frequently prevalent in epidemic form in Asia Minor, China, India, Egypt, Arabia, Northern Africa, Italy, France, Germany, and throughout other parts of Europe. It appeared in Europe for the first time during the reign of Justinian in the sixth century of the present era. Beginning in Egypt in 542 A. D., it passed during the next year to Constantinople and thence, during the remaining half of the sixth century, it spread over pretty much the whole of the Roman world. Ten thousand people are said to have died of it in a single day in Constantinople. Omitting the numerous outbreaks that occurred in the meantime, we encounter the historic visitation of the fourteenth century—the "Black Death"—which, according to Haecker, proved fatal to about 25,000,000 people—a quarter of the entire population of Europe. During its prevalence at Oxford in 1352, two-thirds of the academic population are said to have succumbed.

There is a controversy among writers as to whether the "Black Death" was an uncomplicated epidemic of bubonic plague or not. It appears that a part of the mortality may have been due to malignant typhus fever, a part to the so-

called plague of India, and a part to true bubonic plague. The unsanitary and social conditions of the people at that time were equally predisposing to either one of these pestilences.

During the "Great Plague of London" (1664–65) the total mortality for one year was 68,596 out of an estimated population of 460,000, of whom two-thirds are supposed to have fled to escape the contagion. The mortality rose during this epidemic from 43 in May to 590 in June, 6137 in July, 17,036 in August, and 31,159 in September, after which there was a decline. There was an epidemic of "spotted fever" at the same time in London.

Though Northern Africa is considered the home of the plague, it is interesting to note that the disease has now extended into the southern part of that continent. It has never been known to cross the plains of India. It has never visited America.

The mortality from bubonic plague varies in different epidemics from 53 to 95 per cent.

Race appears to have less predisposing influence than does social condition. It is a disease preeminently of the poor and destitute, its existence and spread being favored by the manifold unhealthy conditions under which this class of society exists.

During the recent epidemic at Hong Kong, China, the deaths were distributed according to sex and age as follows:

Men	62.40	per cent.
Women	19.23	"
Boys	8.92	"
Girls	9.45	"

Telluric conditions seem to have but little influence upon the existence of plague, as it has occurred in alluvial deltas, along calcareous ridges, and on granitic mountains. Nor is it apparently controlled by altitude, for epidemics have occurred both along the low-lying borders of rivers, as along the Nile, the Euphrates, the Volga, and the Thames, and in

the mountains of India and Kurdestan, at elevations of from 5000 to 7000 feet above the sea.

The disease seldom occurs in the tropics. Season has apparently no definite effect upon it. It has been seen to appear and to diminish and disappear during both hot and cold weather.

Dissemination and Modes of Infection.—Plague has arisen so uniformly in unclean places that filth is generally regarded as the most potent factor in favor of its origin and spread. Almost without exception, plague-centers have been characterized by a soil polluted with decomposing animal matters, and by overcrowding of destitute, dirty, and poorly-nourished people. An interesting and important fact that points to the soil as the location of the plague-virus is the observation that usually during, and often preceding, the appearance of the disease among human beings there is an epidemic of plague among rats, mice, and swine, particularly rats and mice.

During the recent epidemic in Hong Kong the locality most affected by the disease had a Chinese population equivalent to 21,618 souls per acre of house-area. The mean size of the main room of a house in this neighborhood was 26 by 14 feet by 10 feet high; such a room served as living-space for from 16 to 25 people. The personal habits of the occupants are described as filthy beyond belief, cleanliness or anything akin to it being apparently an unknown art.

Opinion is divided as to whether the contagion of plague is disseminated through the air. It may be spread by means of infected clothing and other objects that have been in use by the patient. It does not seem to be carried from place to place by means of merchandise. It is most often disseminated from places in which it is either endemic or epidemic to other localities, through human intercourse. It is improbable that the disease is spread to any great extent through the use of infected water or food.

As a result of his investigations at Hong Kong, Aoyoma expresses the opinion that in the great majority of cases, if ... n of the plague occurs through the in-

fection of skin-wounds, and much less frequently than has been supposed by way of the respiratory and alimentary tracts. He points out that during the epidemic physicians and nurses who were in attendance upon infected individuals and who spent much of their time in places where the sick were lodged, rarely became affected; and, further, of 300 English soldiers who volunteered to clean and disinfect the pest-houses, only 10 contracted the disease.

This opinion, with the character of the evidence in support of it, coincides with that of a number of observers who have studied the course of the disease in other localities. Aoyoma does not regard it as probable that an actual pest atmosphere exists, an opinion at variance with that of a number of other writers who insist that prolonged breathing of the air about a plague patient is one of the certain ways of contracting the disease; at the same time they admit that the casual entrance into a room occupied by such patients does not often result in infection.

Prophylaxis.—The most important safeguards against the generation and spread of plague are personal cleanliness, the removal of organic waste from about the dwellings, good drainage of the soil, and the prevention of overcrowding.

When the disease first makes its appearance in a house, the sick should be at once removed to a hospital and there isolated. The healthy members of the household should be quarantined and kept under observation for from ten days to two weeks. In the meantime the house should be thoroughly cleaned and disinfected. The ceiling, walls, floor, and all other surfaces should be scrubbed with a 3 per cent. carbolic-acid or a 1 : 1000 corrosive-sublimate solution. The furniture of the sick should be scrubbed with a 3 per cent. solution of carbolic acid in warm water, and body- and bed-clothing should be steamed for one hour at 100° C.; all articles of little value that have been about the patient should be burned. With regard to the precautions to be taken while in attendance upon the sick, it should be borne in mind that the discharges from suppurating buboes, and possibly the discharges from the bowels or the stomach, are infective.

All objects, therefore, that have been soiled with such matters should be boiled or steamed at 100° C. before being removed from the sick-room.

Since infection most often occurs through abrasions of the skin, care should be taken that infective materials do not come in contact with wounds, scratches, etc., of the hands. The hands should be carefully disinfected after the necessary manipulations of the patient. The great frequency with which the deep glands of the groin were the first to become inflamed, during the late epidemic in Hong Kong, is explained by the fact that the Chinese of the poorer classes wear no shoes, and the virus gained entrance to the lymphatics, passing directly to these glands through small wounds of the skin of the feet. In this epidemic (as in others) the soil was manifestly infected.

Those who die of the disease should be wrapped in a sheet soaked in a 1 : 1000 corrosive-sublimate or 5 per cent. carbolic-acid solution, and either buried or cremated at once.

Those who recover should be kept in quarantine under medical observation for at least a month. Kitasato has found the bacillus of plague in the blood of a patient as long as three weeks after the beginning of convalescence.

Incoming ships from plague-infected ports should be subject to quarantine for a time sufficient to permit of thorough medical inspection. If found to be infected, the sick should be removed to hospital and the healthy members of the crew isolated. The ships should then be thoroughly disinfected. In short, they should be treated the same as an infected house (see above).

There is some question as to the propriety of preventing the free migration of uninfected people from a place in which plague prevails to localities that are free from it. Such emigration enables many to escape the pestilence, and the danger of their introducing the disease into their new abode may be eliminated by a quarantine of sufficient time (from seven to ten days) to demonstrate that none of them are already afflicted with plague. If, after such detention, careful medical inspection, and thorough disinfection of their clothing and

other belongings no cases of the disease are found, these individuals may with reasonable safety be permitted to mingle with the general public.

SUPPURATIVE AND SEPTIC INFECTIONS.

Under this head may properly be included the ordinary suppurative troubles resulting from infection by the common pyogenic cocci—such, for example, as boils, abscesses, phlegmons, etc.; those conspicuous for their migratory tendency, and which are usually due to a particular species of pyogenic cocci, notably erysipelas, lymphangitis, etc.; and those general infections that partake of the nature of septicemia and pyemia, and which may or may not be referable to the common pyogenic cocci.

The treatment of these conditions together is thought advisable, not because of etiological or clinical relationship, but rather because of their common characteristics when viewed from the standpoint of prevention.

The acute, circumscribed, inflammatory processes most frequently result from the activities of the ordinary pus-producing cocci, the most common of which is *staphylococcus pyogenes aureus* (Fig. 14).

This organism is a micrococcus that develops in the form of irregular clusters. Its designation "aureus" signifies that its growth is characterized by a golden or orange color. It liquefies gelatin, coagulates milk, and on both nutrient agar-agar and potato grows as a yellow or orange-colored deposit. It grows at ordinary room-temperature, but better at the temperature of the body. It is tenacious of life, and withstands drying for months. In old cultures it has been known to retain its virulence for as long as a year. It is destroyed in ten minutes by a temperature of 62° C. It does not form spores, though it is usually regarded as one of the resistant

cocci, for the reason that it does not readily succumb to those influences that prove detrimental to most of the non-spore-bearing pathogenic bacteria. In addition there are other varieties of staphylococci that are associated with circumscribed inflammatory conditions. They are markedly less pathogenic than the organism just mentioned. They are designated by names indicative of the color of their colonies,

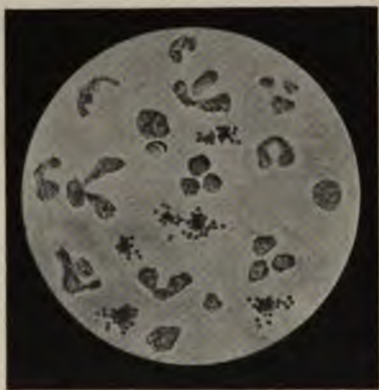


FIG. 14.—Pus showing presence of staphylococcus pyogenes aureus.

as seen under artificial cultivation—viz., *staphylococcus pyogenes citreus*, lemon-yellow colonies; *staphylococcus pyogenes albus*, white colonies; *staphylococcus epidermidis albus*, a staphylococcus frequently present in the epidermis and growing with white colonies.

By particular methods of inoculation suppurative lesions similar to those observed in man may be produced in animals through the employment of cultures of *staphylococcus pyogenes aureus*. In man this organism is the cause of a variety of inflammatory conditions, notably boils, abscesses, phlegmons, osteomyelitis, meningitis, acute ulcerative endocarditis, peritonitis, pleuritis, synovitis, etc. In fact, there is hardly an inflammatory condition in which it has not at one time or another played the etiological rôle.

Those inflammations having a migatory or spreading tendency, though also sometimes due to the organism just men-

tioned, are more commonly characterized by the presence of another of the group of pyogenic bacteria—namely, *streptococcus pyogenes* (Fig. 15), identical in all probability with *streptococcus erysipelatis.*

This organism is characterized by its growth in chains—*i. e.*, it divides transversely in one direction of space, the daughter-cells having the tendency to adhere together like strands of beads. It does not grow luxuriantly under arti-

FIG. 15.—Pus from erysipelas, showing presence of streptococcus pyogenes.

ficial cultivation, its colonies ordinarily being hardly more than very small points. Its growth is not accompanied by the production of color. It does not liquefy gelatin, and in transparent fluid media does not cause diffuse clouding, but grows rather in thread-like clumps that cling to the sides and sink to the bottom of the tube. It grows at ordinary room-temperature and at that of the body. It is not readily destroyed by drying, and has been detected on several occasions in the dust and in the air of hospital wards that have been occupied by patients suffering from infections in which it was present. It is killed in ten minutes by from 52° to 54° C. (Sternberg). It is conspicuous for the variability of its virulence. Cultures are rarely encountered, even in those fresh from diseased tissues, that exhibit marked disease-producing properties in animals. At times it is capable, on inoculation, of causing

general infection, while again the result may be a local abscess or an erysipelatous inflammation about the site of infection. The writer has encountered a culture of this organism that produced, when injected into the circulation of rabbits, diffuse miliary abscess-formations in the muscles, similar histologically to those caused under the same circumstances by *staphylococcus aureus;* while, on the other hand, when rubbed into a wound of the ear of another rabbit a severe erysipelas resulted. The two conditions were not observed coincidently in the same animal.

In general, this organism seems to be much more pathogenic for man than for animals. It has been detected in a number of pathological lesions in man, among which may be mentioned erysipelas, spreading phlegmons, ulcerative endocarditis, puerperal peritonitis, the anginas of scarlatina and of measles, pleuritis, pericarditis, pneumonia, and mixed with the diphtheria bacillus in the diphtheritic false membrane.

The general infections that partake of the nature of septicemia and pyemia, while usually due to the ordinary pyogenic bacteria, are not always to be referred to this cause. There is now a general consensus of opinion that under peculiar predisposing influences a number of different organisms, not usually regarded as pyogenic, may find conditions favorable to their invasion of the body and to their development within the circulating fluids and in the tissues. The wider application of bacteriological methods to the study of septic infections has brought out the important and interesting fact that the lesions found are not specifically related to definite bacterial species, but may, under circumstances not entirely clear, result from the activities of a variety of different species.

The predisposing causes which favor infection by any of the foregoing pyogenic species of bacteria are those which generally tend to depress vitality, viz.: chronic alcoholism, anemia, Bright's disease, diabetes, and severe burns.

Recently delivered women are especially prone to erysipelas and septic infections.

Modes of Dissemination.—The causative micro-organisms are present in greater or smaller numbers in the dis-

charges from all acute inflammatory processes. The pus from old foci of suppuration is sometimes found to be free from living bacteria, though the remains of dead micro-organisms may often be detected microscopically. Under these circumstances the causative organisms have died in the products of their own pathogenic activities.

In the majority of cases the organisms found in the discharges from acute processes are living and capable of lighting up inflammatory conditions when they gain access to wounds. When dried they may be disseminated through the air as dust, and may excite suppuration in abraded surfaces on which they may fall, though this is not now regarded with the same degree of apprehension by surgeons as it formerly was. The modern view concerning the modes of transmission of these conditions is that in the vast majority of cases the disease results from direct contact—that is, through the use of unclean and infected hands and instruments at the time of operation, and through the dressing of healthy wounds with unsterilized materials. In the case of erysipelas it is possible that the infection may be disseminated from the patient during the period of desquamation, the specific micro-organism being conveyed by means of the minute particles of exfoliated epidermis. All surgical accessories are capable of carrying infection, when not rendered free from infective matters by thorough cleansing and disinfection before being employed on fresh wound-surfaces.

Probably the most common mode of dissemination for surgical infections is through the operator, his assistants, and nurses, because of inattention to their own personal condition. Individuals whose duties bring them frequently in contact with matters that are more or less infective may themselves be the agents for carrying such infections, unless rigorous attention be given to the most thorough personal cleanliness and to careful disinfection of the hands before manipulating non-infected cases.

Both the local and general types of surgical infection may and often do follow apparently insignificant wounds with infected objects. So slight an injury, for instance, as the

scratch of an infected pin, or the prick of an autopsy-scalpel, or of an instrument used during the examination of such virulent matters as the exudate of a septic peritonitis, have resulted in a serious and sometimes fatal general infection.

Portals of Infection.—Open wounds, superficial abrasions, and excoriations of mucous surfaces are the common portals of infection. Wounds in which there has been much insult to the integrity of the tissues, and much interference with local nutrition (circulation), are particularly liable to suppurative complications. The results of wound-infections are not necessarily limited to the primary site of invasion. Through the dissemination of infective particles from the point of their entry by way of the blood or lymph-channels, infection may become general, or may occur secondarily as an isolated focus in some one or another of the more remote internal viscera.

It does not follow that every wound which has been exposed to infection necessarily becomes infected. In many cases the weapons of defence provided by nature (vital tissue-resistance) prove to be of sufficient vigor to overcome the invading organisms, in which event primary healing without infection, or with infection to but an inconsiderable degree, occurs; on the other hand, infection occurs when the weapons of offence possessed by the invading bacteria are potent to paralyze the usual vital activities of the tissues. The process of infection must always be viewed as a contest between pathogenic bacteria on the one side, with the toxic products of their growths as weapons of offence, and the tissues on the other, resisting with whatever degree of natural vital energy the circulating fluids and cellular elements may be endowed. All agencies, therefore, that in any way tend to depress this natural vital energy of the tissues, either through their local or their constitutional mode of action, deprive them of their only mode of defence and render them liable to infection.

Prophylaxis.—The prophylactic measures that are of most avail in preventing wound-infection are cleanliness and protection of the injured tissues from infection from without

during the process of repair. These procedures find their field of greatest usefulness in hospitals and dispensaries, where numbers of individuals suffering from injuries and from various surgical infections are congregated together.

Without discussing the details of antiseptic technic as practised by surgeons, it will suffice here simply to indicate the cardinal points to be kept in mind in the prevention of the diseases included in this category.

The hands should always be thoroughly washed and disinfected, after examining an infected wound, before proceeding to manipulate other wounds either infected or fresh. The instruments employed should have been thoroughly cleaned by washing and wiping, and then disinfected—as good a method of disinfection as any other is to boil them for ten minutes in a 2 per cent. sodium-carbonate solution. During the operation or at the dressing the alkaline solution should be rinsed from the instruments with sterilized distilled water before they are used about the tissues. All ligatures (not those of animal tissue, such as catgut), sutures, and bandages should be sterilized by steam before using. They should not be removed from the sterilizer until needed.

Bandages and dressings that are removed from the wound should not be permitted to remain about the room. If, for reasons of economy, they are to be used again, they should be disinfected and finally washed, dried, ironed, rolled, and sterilized by steam. If not to be used again, they should be burned.

It is not generally advisable to employ chemical disinfectants and antiseptics about wounds for the purpose of prophylaxis, for the reason that they usually defeat the very object for which they are employed, by converting the tissues into a nidus favorable to the growth of micro-organisms. By the action of such substances the vitality of the tissues is often destroyed through the induction of necrotic changes, and they are in this way deprived of the means with which nature has endowed them for resisting infection.

VENEREAL DISEASES.

(Gonorrhea and Syphilis.)

Gonorrhea.—A specific inflammation of the mucous membrane of the urethra in the male, and of the urethra, cervix uteri, and glands of Bartholini in the female. It is caused by a micrococcus discovered by Neisser, and commonly known as the "gonococcus of Neisser," or as *micrococcus gonorrhϾ*. This organism is recognized microscopically in gonorrheal pus by its tendency to occur in pairs (diplococci); by its relation to the pus-cells—*i. e.*, by being located within the protoplasmic bodies of these cells (Fig. 16);

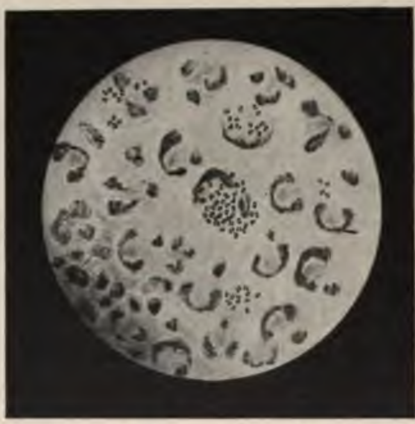


FIG. 16.—Pus of gonorrhea, showing presence of gonococci in the bodies of several pus-cells.

and by its peculiar staining reactions—namely, its failure to retain the stain when treated by the process of Gram, while it stains readily when exposed to any of the ordinary basic anilin dyes. Its failure to stain by the Gram method is one of the most important differential reactions. It can be cultivated, but not on the ordinary nutrient media employed in bacteriological work. (For the methods of cultivation see recent works on Bacteriology.)

When kept at body-temperature artificial cultures of this

organism have been observed to retain their vitality for as long as a month; whereas at ordinary room-temperature they die in about forty-eight hours.

It is destroyed in a few hours by drying. It is non-pathogenic for animals. Both gonorrhea and conjunctivitis have been produced in man through the use of pure cultures of this organism.

Syphilis.—A chronic infectious disease characterized by manifold pathological lesions, of which the chancre, the mucous patch, and the gumma are the most destructive.

Though numerous claims have been made for the discovery of micro-organisms that stand in causal relation to the disease, its etiology is still unknown. Of these claims, the one that has received the greatest consideration is that of Lustgarten. He described as the cause of syphilis an organism that he had discovered microscopically in the primary sore, in the secretions of syphilitic ulcers, and in other syphilitic lesions. This organism is a bacillus possessing many of the characteristics of *bacillus tuberculosis*, and evidently belonging to the group of which the tubercle bacillus is the most important member. In many respects it is identical with a bacillus, morphologically like it, that is commonly present in the smegma from about the prepuce and labia. It likewise has peculiarities that are common to the bacillus of leprosy. The four organisms mentioned—viz., *bacillus tuberculosis*, *bacillus smegmatis*, *bacillus lepræ*, and *bacillus syphilidis*—are distinguished microscopically from one another by particular processes. (For the differential method see works on Bacteriology.)

The so-called "syphilis bacillus" has not been isolated in culture, nor has the disease been reproduced in animals by inoculation with secretions from syphilitic ulcers, or with bits of syphilitic tissue. Lustgarten's claim rests simply upon the finding of this organism in syphilitic lesions by microscopical methods. Though certain other observers have confirmed Lustgarten's observations, a great many more have failed to detect the organism after careful search through the most promising materials. There is therefore considerable room

for doubt as to the causal relation of this organism to syphilis.

Dissemination, Modes of Infection, etc.—In the vast majority of cases, both gonorrhea and syphilis are disseminated through actual contact with the secretions of diseased tissues during sexual intercourse. The introduction of gonorrheal pus into the eye results in a serious variety of purulent ophthalmia—viz., gonorrheal conjunctivitis, and a condition (ophthalmia neonatorum) not rarely seen in the new-born of women affected with gonorrhea, may, and often does, result in loss of sight unless promptly and judiciously brought under medical treatment. It is not unlikely that gonorrheal ophthalmia may be contracted through the use of towels that have been employed by persons suffering from gonorrheal urethritis. Syphilis may be disseminated, in addition to the usual way, through kissing and through the use of drinking and eating utensils that have been used by persons suffering from syphilitic lesions of the buccal mucous membrane. It may be contracted by the wet-nurse who suckles a syphilitic child, or may be given in a variety of ways by a syphilitic nurse to a healthy baby that is placed in her care.

It is occasionally contracted by physicians in the performance of professional duties, through the infection of wounds in the hands with syphilitic secretions.

Attention of dentists has been called to the possibility of their disseminating this disease from persons suffering from lesions of the oral cavity, unless proper precautions be taken. Bulkley has called attention not only to a case of syphilitic infection transmitted in this way, but also to one in which the operator himself contracted the disease through infection of a wound of the finger.

In short, abraded surfaces when brought in immediate contact with the blood or secretions from primary or secondary lesions, in any way whatsover, are practically certain to become infected. Syphilis may be transmitted by heredity.

It may be inherited from the father, the mother being healthy, or from a syphilitic mother. A most interesting

phenomenon is that embodied in Colles's Law—viz., "a child born of a mother who is without obvious venereal symptoms, and which, without being exposed to any infection subsequent to its birth, shows this disease when a few weeks old—this child will infect the most healthy nurse, whether she suckle it or merely handle and dress it; and yet the child is never known to infect its own mother, even though she suckle it while it has venereal ulcers of the lips and tongue." Hereditary transmission of the disease is most apt to occur when conception takes place during the primary stages of the disease. Syphilis in a parent may have apparently disappeared under treatment, and yet offspring born subsequently may manifest inherited evidences of the disease.

The mortality among children born of syphilitic parents is high. Kryhus[1] states that in the Hospital St. Louis 24 per cent. of syphilitic women abort, and in the Hospital Lourcine 38 per cent. are liable to this accident. Of children born of syphilitic fathers 48 per cent. die, while 78 per cent. succumb when both parents are affected with the disease. The infantile mortality decreases with increase of chronicity of the disease in the parents. Fournier states that in many hospitals of Paris the mortality among infants born of syphilitic parents reaches 84 to 86 per cent.

Prophylaxis.—That the vast majority of venereal diseases originate through impure and irregular sexual intercourse is a statement over which there can be little controversy.

It is not my purpose to discuss here the moral aspect of prostitution; neither are we to be understood as endorsing the evil by stating that it has existed as long as peoples have existed, and from the present outlook there is little likelihood of its disappearance. In view of the moral, social, and physical ravages that follow in the wake of venereal diseases, it behooves us to employ every measure that is within our power to combat these maladies and lessen their frequency.

The trustworthy personal measure against venereal diseases, as contracted in the usual way, is celibacy, and it is

[1] *Thèse de Paris*, 1890.

the duty of the physician to teach this doctrine, even though he may feel that its adoption is in many cases a matter of grave doubt; not because continence is an impossible condition, but rather because for many men it involves a kind of personal discipline that they are loath to undertake. Sexual desire is often one of the manifestations of stored-up energy resulting from idleness and intemperance. The greatest aids to a continent life are hard work, athletic exercise, temperance in food and drink, and the avoidance of temptation. For many men celibacy for an indefinite period is apparently impossible. Such men should be advised to marry, even though personal sacrifices in certain directions must be made by so doing.

That a large proportion of unmarried men prefer to satisfy their sexual cravings by recourse to the usual method, rather than endeavor to repress them, is a fact that cannot be ignored; and while the recommendation of personal preventive measures to meet the exigencies of such cases may appear as favoring immorality, it must be remembered that the task now in hand is the prevention of disease, and not the enforcement of moral precepts. Under such circumstances something may be done to prevent contagion by scrupulous cleanliness and careful local disinfection after intercourse; but it must also be borne in mind that none of these measures affords certain protection. In a number of European towns, especially in France, the use of disinfectant lotions by prostitutes is rigorously enforced, with the result of considerably reducing the frequency of venereal diseases.

The prophylactic measures of greatest efficiency are administrative. The question of prostitution is a matter for the State to consider in its relation to the public health. A person afflicted with a venereal disease is a menace to the public health, and is just as much a subject for State control as would be a case of small-pox or of any other communicable malady. In the majority of European countries laws have been enacted that aim to limit the dissemination of these diseases, and in the main their effect has been most salutary. These laws provide for the registration, usually at a bureau

of the department of police, of all women who subsist by prostitution; for (in some places) their segregation in brothels or in particular parts of the town; and for their regular and frequent examination by competent physicians who are detailed for the purpose. In addition, the law should provide for the treatment, without cost to the individual, of all venereal cases in hospitals properly equipped for the purpose.

In France, Germany, Denmark, and England (prior to the repeal of the Contagious Diseases Act in the last-named country in 1884) the relative frequency of venereal diseases has markedly diminished as the methods of municipal control of prostitution have gained in efficiency. Nevertheless, the enactment of these laws, operating manifestly for the public good, has given rise to no end of controversy, and has in some places (particularly in England) met with vigorous opposition from those who, fully aware of the existence of an evil that cannot be eradicated, consider it as immoral to sanction the only feasible plan for diminishing its baneful influence upon the physical well-being of the community. Where such laws have been enacted and enforced, their result, more particularly upon the number of syphilitic infections, has been most marked. This was conspicuously noticeable at those army-posts in England that were under the Contagious Diseases Act prior to its repeal in 1884.

An element that disturbs the still more successful operation of the law is everywhere recognized in clandestine prostitution that always obtains among women of a certain class. It is usually impossible to bring all such women under the operation of the law, though the experience of a number of places shows that many of this class, realizing the material advantages to be derived from skilful medical control and attention, have voluntarily presented themselves for registration. Moreover, there is reason to believe that the frequent and dignified medical inspection has in general an educational influence upon public women. They realize that they are under restraint; they take better care of themselves, for they are sent to hospital if found diseased, and their trade is necessarily thereby interrupted; and, while perhaps no better off

morally, they are less frequently guilty of breaches of public decency. At least, the experience of a number of places has led to this opinion.

The experience of those communities in which laws for the regulation of prostitution have been enacted has brought out two important facts—viz., that the unlicensed, uncontrolled public woman is the great source of dissemination of venereal infection, and that by the enforcement of carefully constructed municipal laws the amount of venereal disease may be materially diminished.

The results of medical examination of prostitutes in those places in which registration is in force clearly illustrate the dangerous nature of those women who are not regularly within the operation of the law; for instance, Commengué states that of 913,291 registered medical examinations of prostitutes in Paris between the years 1878 and 1887 syphilis was found to be present per 1000 examinations 3.12 times in registered prostitutes living privately, 2.70 times in registered prostitutes in brothels, 23.96 times in work-girls, and 166 times in prostitutes not under control. Essentially the same proportions held for gonorrhea, except in the case of work-girls, when it was found to be 144.6 for 1000 of all examinations. In Lyons Giraud found that from 1.34 per cent. to 1.61 per cent. of registered women were diseased, while 33.11 per cent. of those not under control were suffering from venereal troubles. In Denmark (1889) venereal diseases were present in 4.27 per cent. of registered women under control; in 17.64 per cent. of non-registered women who voluntarily presented themselves for examination; and in 39.49 per cent. of clandestine prostitutes not under control and not regularly examined. Illustrative of the influence of these laws: when the registration laws were passed in Rostock in 1881, the number of cases of syphilis that applied for medical advice in that year was 240; during the six succeeding years, under the influence of the law, the number of cases was 269 in 1882, 164 in 1883, 113 in 1884, 92 in 1885, 92 in 1886, and 70 in 1887.[1] While the Contagious Diseases Act

[1] *Hygienische Topographie von Rostock*, 1889.

was in operation in England (1864–1883), the amount of syphilis was markedly diminished. Since the repeal of the Act in 1884 venereal diseases in the army have reverted in extent and severity to what they were before the Act was passed. According to Balfour the admissions to army hospitals in 1864 (the year before the enactment of the law) for primary chancre were 108.6 per 1000. In 1872 the admissions at the *uncontrolled* stations were still higher—viz., 123.2 per 1000—while in the same year the admissions at the army stations that were *under* the control of the Act were only 53.3 per 1000.

Parke states that the number of admissions to the hospitals of all military stations *under* the Act (comprising a total of 30,765 men) from 1867–72 for primary venereal sore was 62.8 per 1000, while the admissions from these same stations just after the repeal of the Act were 110 per 1000 in 1883 and 138 per 1000 in 1884. "So that things are rapidly falling back into their old evil conditions." Such statistics as the foregoing require no comment. They tell their own story.

As has already been said, to many it may appear improper to advocate a method by which the community acknowledges and openly licenses a practice that is plainly a breach of public morals. But the evil exists; it is likely to exist; and nothing is gained—on the contrary much is lost—by calmly closing the eyes to it. The evils of prostitution are more far-reaching and are a greater menace to the public health, morals, and happiness than a superficial examination would indicate. It is our duty as physicians and as citizens to circumvent this evil, and we can do this only by seriously recognizing it, not by ignoring it.

As Osler aptly puts it: "If the offender bore the cross alone, I would say forbear; but the physician behind the scenes knows that in countless instances syphilis has wrought havoc among innocent mothers and helpless infants, often entailing lifelong suffering. It is for them he advocates protective measures."

LEPROSY.

Definition, Cause, etc.—A chronic, endemic, infectious disease caused by a specific micro-organism, *bacillus lepræ*, which possesses certain peculiarities in common with *bacillus tuberculosis*.

The disease occurs in three forms, viz.:

1. The tubercular leprosy, in which nodular eruptions occur on the skin of the face, limbs, breasts, scrotum and penis, and also on the mucous membranes.

2. The non-tuberculated or so-called "anesthetic leprosy," in which the peripheral sensory nerves are at first involved. This is followed after a time by a peculiar, flat, dry, scaly eruption on the back, shoulders, posterior surfaces of the arms, about the nails, and at times along the course of the nerves. In the earliest stages the affected areas are hyperesthetic; during the eruptive stage they become anesthetic.

3. Mixed tubercular leprosy—*i. e.*, a combination of the two forms just mentioned. This is the least common manifestation of the disease.

The non-tubercular or anesthetic variety is that most frequent in the Tropics.

Bacillus lepræ, now generally believed to be the cause of the disease, was discovered in the pathological lesions of leprosy by Hansen and by Neisser between 1879 and 1881.

Morphologically, it is so like *bacillus tuberculosis* as to be practically identical with it, though some authors consider it to be shorter, a distinction that alone counts for but little. It is said to be differentiated from *bacillus tuberculosis* by special staining reactions. Though several authors (Bordoni-Ufreduzzi, Ducrey, and Campana) claim to have cultivated this organism, it is doubtful if it has ever been grown artificially. In fact, such a number of efforts to cultivate it from skin-lesions by trustworthy investigators have resulted in failure, that the general impression now is that the majority of the bacilli seen in the tissues are dead. At all events, one of their most frequent microscopical peculiarities is a conspicuous degree of apparent degeneration.

On microscopical examination with low magnifying powers of sections of leprous tissue stained by any of the methods used for staining tubercle bacilli in tissues, the leprosy bacillus is detected usually in enormous numbers. It will be seen scattered through the tissue as smaller and larger clumps of individual bacilli (Fig. 17). On examining these clumps under a high magnifying power, they will usually be

FIG. 17.—Schematic representation of section through a lepra nodule: left side of picture gives appearance under low magnifying power; right side, the appearance when highly magnified. In the latter the large lepra cells are diagrammatically indicated.

found to represent single granulation-cells that are packed with the bacilli—the so-called "lepra-cells"—of which a large part of the new growth is composed. The bacilli are irregularly stained, often irregular in outline, beaded and broken, and, as said, usually present the appearance of degeneration. The bacilli are also present in the secretions that may exude or be squeezed from the leprous nodule *in situ.* They have been found in the circulating blood, but only in very small numbers. Sticker found them in the nasal discharges from 128 out of 153 cases examined by him. In only 23 of these 153 cases did he find them in the sputum. They may be detected microscopically by the ordinary methods used for the detection of tubercle bacilli in sputum or in pathological secretions.

The disease has never been reproduced in animals by inoculation with fresh leprosy tissues or secretions. The efforts to reproduce the disease in man by inoculation with fresh leprosy tissue have been hardly more successful.

During the past fifty years an astonishingly large number of individuals have permitted themselves to be inoculated with the pathological products of the disease without leprosy resulting in but a single instance, and there is doubt as to this individual's freedom from the disease at the time of his inoculation. In his résumé of the literature on this subject Walters[1] cites at least 73 authenticated inoculations of human subjects. Some of these were in good health, others suffering from other maladies, and others already leprous, the inoculations in the last instance having been made on non-affected parts of the body. In not a single case did leprosy result.

The much-quoted case of Arnig, in which leprosy appeared in a man sixteen months after he had inoculated him, loses much of its value as a demonstration that leprosy may be induced in this way, by a closer study of the conditions under which the test was made. The subject, a Hawaiian convict, had a family history of leprosy, several relatives having died of the disease. Arnig himself does not consider the results of his inoculation as a demonstration free from objection.

Geographical Distribution, Race, etc.—Leprosy is endemic in Japan; on the coast of China; throughout India and the Indian archipelago; in isolated districts along the coast of Africa, especially that of western, northern, and northeastern Africa, though it is also found in Cape Colony; along the southern shores of the Black Sea; throughout the Greek archipelago; along the western coast of Norway; in Iceland; in certain parts of New Brunswick and Nova Scotia; in Mexico; among the Chinese in southern California; in Louisiana; in the West Indies, especially Cuba; in Brazil, and in the Argentine Republic and the neighboring districts.

[1] *Centralbl. fur Bakteriologie und Parasitenkunde*, 1893, Bd. xiii., S. 469.

The character of the disease varies somewhat according to location—viz., in the temperate and colder climates tubercular leprosy is the predominating form, while in the tropics the anesthetic variety is more common. While occurring at all ages and among all classes of people, it is seen oftenest among the poor and destitute. According to Hirsch, the disease is usually encountered in countries of heterogeneous populations, negroes and those of mixed blood being much more frequently affected than are Europeans. In certain localities in the Orient, where the disease is endemic, the Arabs and pure-blooded East Indians have shown a peculiar insusceptibility to it.

In the colder climates, as in Norway and Iceland, the purity of the race has no apparent influence upon the frequency of the disease.

Hirsch calls attention to the peculiar differences that are seen in the reaction of the Jewish race to leprosy in different parts of the world. In Jamaica, St. Vincent, and Surinam, the frequency of the disease among the Jews is second only to that seen in the negroes; while in Syria, Damascus, Jerusalem, Bombay, and other places they are but rarely affected.

Dissemination, Modes of Infection, etc.—While no doubt exists as to the infectious nature of leprosy, there is little agreement of opinion as to its mode of dissemination.

The disease shows no special tendency to spread beyond the boundaries within which it is endemic, and healthy individuals are known to have spent long years of intimate association with lepers without contracting the disease.

Many of those who have investigated the subject are of the opinion that leprosy is rarely, if ever, transmitted from the diseased to the healthy person by direct contact, while other observers claim this to be its most frequent mode of transmission.

The mass of evidence compiled by Hirsch in opposition to its transmission by contact is very strongly in favor of the view that this must be a very unusual mode of dissemination, if it occurs at all.

Some believe that, as in the case of syphilis, one may often

be in intimate association with the diseased persons for long periods without becoming infected, but finally in some inexplicable way the disease is contracted. It has been suggested that, like syphilis, there may be periods when leprosy is eminently communicable, while in other stages this peculiarity is diminished or lost. There is a pretty general agreement of opinion that the anesthetic is much less readily communicable than is the tubercular variety of leprosy.

The disease starts with no primary sore or point of invasion that can be accurately determined. Its usual mode of onset as multiple foci leads to the opinion that through some unknown channel a number of areas in the skin must have served simultaneously as points of deposit for the morbific causative agent. Whether such infection is from without, or starts from some primary focus, the nasal mucous membrane for instance, as is believed by Sticker, cannot be positively affirmed. Nor can it be definitely stated that leprosy is contracted by way of the lungs or alimentary tract, though some observers believe this possible. The negative results that have followed inoculations in human beings lead to the opinion that it cannot be transmitted by inoculation; though Hansen is of the opinion that it is often contracted through abrasions of the skin, through the wearing of clothing that has been worn by lepers, and through the intimate association between the sick and the well, that is often observed among the ignorant and destitute.

The increase of leprosy in late years in the Sandwich Islands is held by some to be the result of direct transmission, occurring very often through sexual intercourse.

At the first Leprosy Congress held in Berlin in October, 1897, various speakers on the subject expressed the belief that the disease could be contracted by way of the mucous membrane of the nostrils, and the skin about the face; through wounds of the skin; that it could be disseminated from the infected individuals through saliva and mucus from the mouth and nose; that it could be transmitted by the handling of infected clothing; that it could be carried by in-

sects; and that it could be conveyed through the milk of the nursing mother to her child.

The perpetuation of the disease is believed, by those who oppose the idea of its transmission by direct contact, to be due to heredity. On this point, too, there is divergence of opinion, though no one denies that inheritance is *one of the ways* through which it is disseminated. Hirsch, as a result of his investigations, believes inheritance to be the only demonstrated mode of transmission for leprosy, and in this opinion a number, though by no means all, of the most competent authorities concur.

The opinion has been advanced that certain articles of food, notably fresh, salted, and rotten fish (Jonathan Hutchinson), pork, and decomposed rice, are especially predisposing to the disease. Investigation readily demonstrates the fallacy of this view. In several of the areas of distribution fish, in one form or another, is the staple article of food for the entire population, and yet leprosy does not spread beyond the confines of the isolated districts in which it is endemic.

It has also been erroneously claimed that certain atmospheric conditions favor the existence of the disease. No connection can be established between leprosy and climate or season. While frequent along the coasts, its general area of distribution disproves a necessary dependence upon littoral conditions.

Prophylaxis.—It is manifest that without a clearer understanding of the mode of dissemination and the portals of infection of a disease, any measures that may be recommended for the prevention of its spread are of necessity unsatisfactory and incomplete. From what has been said as to the disagreement of opinion concerning the communicability of leprosy, we are prepared for irregularities in the methods employed in its management. In some places no attention is paid to the disease at all; the lepers mingle with the general population and enjoy the same liberty as do the unaffected citizens. In other places efforts are employed to separate them from the people at large by systems of segregation, as in colonies, or upon farms, or in asylums. The Eng-

lish Leprosy Commission considers compulsory segregation as unnecessary, while the unanimous opinion of the First International Scientific Leprosy Conference (Berlin, October, 1897) was: "That segregation is the best means of preventing the spread of leprosy, and that for all countries in which the disease exists (endemically) it is further recommended that compulsory notification, medical supervision, and isolation of individual cases be enforced."

Notwithstanding the fact that obligatory segregation or isolation has never been practised in Norway, the disease has, through intelligent management, been markedly diminished. His observations in Norway lead Hansen to the opinion that the spread of leprosy may be very much checked by scrupulous cleanliness, both personal and domestic, on the part of the patient; by the observation of this the patient can in large measure isolate himself in his own home.

Where destitute lepers are present in number, it becomes the duty of the State to provide for their care in properly equipped isolation hospitals or asylums, or in carefully regulated colonies. According to the demands of the case, isolation under these circumstances may be partial or absolute.

At the Berlin Conference attention was also attracted to the importance of regarding the diseased tissue as a source of infection to others, and with this in view it was recommended that the dissemination of infective materials from these tissues be prevented by the use of antiseptic ointments, bandages, and dressings.

If in countries where the disease is endemic, the public be educated to the full appreciation of its dangers, as Hansen has taken great pains to do in Norway, isolation and segregation may be forced upon the lepers without legal aid—that is to say, by refusing to employ them, by refusing to assist them, by denying their admission to public buildings, conveyances, etc.—they are finally driven for self-preservation to separate themselves from the general public.

Lepers should, if possible, be induced to live apart from the healthy population, preferably colonized in some agricultural district. Such colonies should be provided with hos-

pitals or lazarettos properly equipped for the management and study of such cases as require medical aid. Where segregation of lepers has been insisted upon, the number of cases in the locality has almost uniformly decreased.

As in the vast majority of cases the disease is apparently transmitted by heredity, the marriage of lepers should always be discouraged, and, if possible, be prevented.

They should be prohibited from following such occupations as that of barber, laundryman, provisioner, etc., that bring them in more or less immediate contact with healthy persons.

TETANUS.

(*Lock-jaw.*)

Definition, Cause, etc.—An acute infectious disease caused by a specific micro-organism—*bacillus tetani*—and characterized by frequent and long-continued spasm of the voluntary muscles.

The causative agent—*bacillus tetani*—was discovered by Nicolaier in 1884, through the introduction of garden earth beneath the skin of mice. He demonstrated that the pus or other exudate found at the site of operation in the tetanic mice was capable of inducing the disease in other animals into which it might be introduced. The bacillus of tetanus was not isolated in pure culture until later (1889), when Kitasato separated it by special anaerobic methods from the other forms with which it is usually associated, and proved its causal relation to the disease, by the inoculation of susceptible animals with the pure cultures.

The bacillus of tetanus has been detected in the soil of many localities. It is pretty generally distributed in the upper layers of the earth, though in some places it is much more numerous than in others. It can usually be demonstrated in the soil of gardens that are fertilized with animal manure. These facts explain the occasional onset of tetanus

after wounds into which earth has gained access, such for instance as punctured or lacerated wounds of the feet and hands by old rusty nails, wooden splinters; crushed wounds from the wheels of wagons, carts, etc.

It is a motile, spore-forming, anaerobic bacillus that possesses the morphological peculiarity, when in the spore-stage, the only condition by which it is recognizable microscopically, of presenting the appearance of a small pin—*i. e.*, the oval, glistening, unstained spore occupies one end of the rod, and serves as the head, while the slender stained body of the bacillus forms the rest of the pin-shaped structure (Fig. 18).

FIG. 18.—Bacillus tetani from artificial culture.

The spores of *bacillus tetani* are very tenacious of life. They are not destroyed by drying, even by absolute drying in the dessicator, for months. They are killed in five minutes by steam at 100° C., but they resist moist heat at 80° C. for one hour. They are not destroyed by immersion in 5 per cent. carbolic acid for ten hours, though they are killed in fifteen hours by this treatment.

The vegetative form of the organism as studied in pure culture is found to be by no means so resistant to detrimental agencies as are the spores.

As it is an obligate anaerobe (not growing in the presence

of free oxygen), it requires special methods for its isolation and cultivation. (See works on Bacteriology.)

After the subcutaneous inoculation of mice, rabbits, and guinea-pigs with pure cultures, with particles of earth, with secretions from a wound, or with bits of tissue containing this organism, typical tetanus supervenes in from twenty-four to thirty-six hours, and usually ends fatally in from two to three days. As a rule, the spasms begin in the muscles nearest the site of inoculation. In animals suffering from experimentally induced tetanus the slightest tap on the cage or the least disturbance of the body usually suffices to bring on the characteristic muscular contractions. At autopsy one may find either an area of suppuration or very slight, often hardly distinguishable, inflammatory reaction at the point of operation. The suppuration is not the result of pathogenic activities of the tetanus bacilli, but rather of other, pyogenic organisms, that the earth contained. In many cases the bacilli may be detected microscopically and isolated by culture methods from the tissues at the site of inoculation, but almost as often they are missed.

From the experimental standpoint, this disease is of much historic interest, since it was while investigating tetanus that Behring and Kitasato made the observation from which have been elaborated the principles underlying the employment of the serum of artificially immunized animals for the cure of disease.

Geographical Distribution, Season, Race.—In both the eastern and western hemispheres tetanus is much more frequent in tropical than in the temperate and colder climates; though it often occurs in subtropical localities, as, for instance, in the southern part of the United States, where, according to all accounts, it is at times a very formidable disease. Among the inhabitants of certain of the Antilles islands, in Guiana, Brazil, and Peru, tetanus now and again occurs with such violence as almost to assume an epidemic character.

The race that conspicuously suffers from tetanus is the negro. Whether this is due to a particular vulnerability of the black man to this variety of infection or not it is difficult to

say; but certainly his preference for hot climates, his social condition, his careless personal habits, his insufficient clothing, and his constant exposure to the character of injuries that are known to be most often followed by tetanus, are important factors in favoring the frequent occurrence of the disease among this people. The disease is more common in spring and summer than at other seasons of the year. Its onset, according to many writers, seems to be especially favored by sudden and extreme fluctuations in the weather, as by cold nights following upon hot days, by the sudden occurrence of cold rains after a hot spell, and by cold, moist winds during the summer months.

Indeed, practically all writers on this disease, prior to the discovery of its bacterial origin, regarded atmospheric influences as the most important etiological factor. Nowadays little weight is given to this supposed predisposing influence of meteorological and climatic conditions. Special telluric conditions do not appear essential to the existence of the specific virus.

The majority of domestic animals are susceptible to tetanus, and instances are recorded in which the disease was apparently endemic in particular stables. The occurrence of tetanus among grooms and others in close association with horses and cattle is probably due to infection of insignificant wounds with soil containing the tetanus bacillus, and not to their association, *per se*, with animals, as has been suggested by some who believe in the animal origin of the tetanus virus.

Dissemination, Mode of Infection.—Though an infectious disease, tetanus is not communicable from person to person, save by direct inoculation. The disease is contracted through infection of wounds with matters containing *bacillus tetani* or its spores. The commonest of such wounds are those occurring about the soles of the feet and the palms of the hands, though the disease may result, and has resulted, from the infection of wounds in other parts of the body. Frequently the wound is so trivial at the time of its reception as not to attract attention, and no notice is paid to it until the

remote effect—general tetanus—has set in. Often no history of injury in cases of tetanus can be obtained, either upon examination of the body or by questions put to the patient; these cases are generally classed as "idiopathic tetanus," though it is difficult to conceive that the disease can originate without an antecedent trauma that has served as the portal of entry for the specific micro-organism; or that it can be perfectly simulated, and prove fatal, by some other malady etiologically distinct.

Among the negroes in the tropics and in the southern States tetanus in new-born infants (tetanus or trismus neonatorum, as it is called) often occurs with alarming frequency. It is practically always due to direct infection of the navel through want of cleanliness and general carelessness in management. In the southern States the deaths from this cause among negro infants have been reckoned at from 3 to 4 per cent. of the total mortality from all causes. At times in Jamaica 20 to 25 per cent. of all negro infants born die of trismus neonatorum.

Prophylaxis.—The prophylactic measures against tetanus include those generally employed against wound-infection. In addition there should be proper covering for the feet, for the disease more often results from injury to the bare or imperfectly shod and dirty feet by nails, splinters of wood, and the like, than from any other cause. Similar injuries to the hands often result in tetanus. In short, all punctured or lacerated wounds of the extremities, into which particles of earth are likely to have entered, should be regarded as possible sites of this particular infection. They should be carefully cleansed and otherwise cared for, no matter how insignificant and trivial they may appear at the time of their reception. The discharges and dressings from the wounds of tetanus patients contain the specific infective organism, and they should be considered as dangerous. Dressings should be burned.

ANTHRAX.

Definition, Cause, etc.—An acute specific disease, due to infection by *bacillus anthracis*.

As a disease of animals, especially of herbivora, it is probable that anthrax has been known since very early times. It is one of the most widely distributed pests, both geographically and zoologically, of which we possess any knowledge. A trustworthy and complete conception of its cause, pathology, modes of perpetuation, dissemination, and infection, however, has been rendered possible only through the application of precise methods of modern investigation. The evolution of our real knowledge of anthrax began with the discovery of rod-shaped bodies in the blood of animals dead of the disease by Pollender in 1855, and the demonstration that these bodies stand in causal relation to the malady by Davaine in 1863.

Man, as well as practically all domestic animals, is susceptible to anthrax. The bacillus of anthrax is a large, rod-shaped organism, with square ends that may readily be detected microscopically, by the ordinary methods of staining, in the blood and internal organs of animals dead of the disease, and often in the lesions and secretions from the site of infection in man. In the blood of animals it is seen as single rods or as from 2 to 4 individual rods joined together (Fig. 19); it rarely occurs as longer threads, under these circumstances. Though readily forming spores under the conditions of artificial cultivation, spores are not found during life in the body of the infected animal. *Bacillus anthracis* is not motile.

It can easily be isolated by the usual culture methods, as it grows readily and luxuriantly on all nutrient media in ordinary use for bacteriological purposes.

Neither its morphology nor its appearance in cultures is alone sufficient for its identification, since in each of these respects it is closely simulated by one or two saprophytic forms of bacteria that are commonly present in the soil. It can be recognized with certainty by its effects upon animals.

White mice, common house-mice, guinea-pigs, and rabbits are markedly susceptible to infection by it, and usually the least particle of a typical culture of *bacillus anthracis*, when deposited beneath the skin of any of these animals, suffices to induce a septicemia that ends fatally in from eighteen to thirty-six hours. The autopsy reveals a wide-spread area of edema about the site of inoculation (this is most common in rabbits) and the general distribution of bacilli throughout

FIG. 19.—Bacillus anthracis in blood.

this area, as well as their presence in the blood and internal viscera.

Bacillus anthracis is markedly tenacious of life, particularly when in the spore stage—a state into which it enters as soon as conditions arise that are not conducive to its normal multiplication as vegetative cells. The spores of this organism may be dried for years at ordinary temperatures—*i. e.*, between 12° C. and 40° C.—without losing either vitality or virulence. They withstand such detrimental influences as heat, cold, the antagonism of other bacteria, etc., to a remarkable degree. They germinate, other conditions being favorable, at from 12° C. to 38° C. They resist the temperature of streaming steam (100° C.), at times, for as long as twelve minutes (v. Esmarch), though, as a rule, this temperature is destructive to them in from two to four minutes. Dried

spores are more resistant to heat than are those in a moist condition. They are not destroyed by corrosive sublimate in 1 : 1000 solution in less than twenty-four hours, and they have been shown to resist the action of 5 per cent. carbolic acid for as long as thirty-seven days. The vegetative forms of this organism, when no spores are present, are killed in ten minutes by 54° C.

From what has been said it is manifest that articles contaminated by spore-containing matters from about animals or man infected with anthrax, need to be most carefully manipulated in order to eliminate completely the possibility of their further disseminating the disease. Herbivora, omnivora, and certain carnivora are susceptible to anthrax, the degree of susceptibility being greatest in herbivora and least in carnivora. White rats are but slightly, if at all, susceptible; many birds and, particularly, all cold-blooded animals are insusceptible.

As occurring in animals, anthrax is a septicemia—*i. e.*, the blood is the principal field of multiplication of the organisms. Animals infected with anthrax frequently suffer from hemorrhages from the bowels; the blood thus lost contains the bacilli in greater or smaller numbers.

As discharged from the body the specific organism is not in the spore-stage, but it readily enters this stage under the conditions of the soil that are unfavorable to its further vegetation. In this manner the soil over which such cattle are grazing becomes infected and serves as a means of perpetuating the disease among the herd and of disseminating it to other cattle that may subsequently be pastured on the same land. Infection commonly occurs through tiny scratches and wounds of the lips, tongue, and cheeks, received by the cattle while grazing over the infected focus. It is likely that the disease is sometimes carried by insects, such as flies, lice, ticks, etc.

Anthrax in Man.—Anthrax is a comparatively rare disease in man; and man is apparently less susceptible to it than are most of the domestic animals.

It never occurs spontaneously, but is always the result of

direct infection. It is most frequent in grooms, tanners, shepherds, butchers, herdsmen in general, cattle-dealers, and in those whose occupation brings them in close contact with raw animal-products.

In man the disease occurs as "external anthrax," due to the infection of surface-wounds by the specific morbific agent, and as "internal anthrax," due to the swallowing or inspiration of dust contaminated with the spores of the organism.

In external anthrax (malignant pustule) resulting from infected wounds, usually of the face, neck, hands, or forearms, the disease may run its course as a localized carbuncle that heals slowly, without constitutional symptoms, and sometimes with but slight pain. Or, as is more often the case, the local lesion becomes surrounded by a progressive zone of edema, the lymphatics become involved, and symptoms indicative of general infection make themselves manifest. Secondary lesions of the stomach and intestines may occasion bloody vomiting or diarrhea; those of the brain are evidenced by cerebral disturbance. A rapid extension of the edema from a local lesion of the face or neck to the larynx or thoracic cavity results in distressing dyspepsia, and at times proves fatal. Death may ensue from collapse, due to general infection, or from either of the secondary manifestations mentioned above. By both microscopical and culture methods the specific bacillus may usually be detected at the site of infection, and in the organs in those cases that prove fatal. In cases that recover, the bacilli are often missed, or if found microscopically they present the appearance of degeneration. Very frequently it is impossible to cultivate them from the local lesion in such cases, unless the effort be made very early in the onset of the disease; and then mixed cultures —*i. e.*, cultures of anthrax bacilli together with pyogenic bacteria and ordinary saprophytic varieties—are usually obtained.

A rarer manifestation of the disease is that known as *malignant anthrax edema*. In this form there is no primary papule or vesicles; there is extensive edema of the eyelids, face, neck, hands, or arm. The edema may be wide-spread

and result in gangrene of the affected parts. It may follow the constitutional symptoms. These cases are frequently fatal.

Internal anthrax assumes two forms—viz., the intestinal, known as "mycosis intestinalis," and that which manifests itself more especially through pulmonary symptoms ("wool-sorter's disease"). The former occurs through the ingestion of meat or milk from diseased animals, and through the swallowing of infected dust; while the latter is seen among workers in infected hair, hides, and wools, resulting most likely from the inhalation of dust containing anthrax spores. The wools that are especially looked upon with suspicion, from this standpoint, are those imported from Russia and South America.

Prophylaxis.—The most trustworthy modes of exterminating the disease are cremation and burial of the carcasses as soon as possible after death. The preferable method is the latter, as the body can be buried whole, and there is thus less liability of further pollution of the soil with blood and other fluids from the tissues; while for cremation or disinfection by heat or chemicals the animal usually needs to be cut into pieces of convenient size to be handled, a process that results in the spreading about of the infective agents through the blood and fluids that escape during manipulation. The body should be buried *uncut*, not less than six feet below the surface. After this procedure the vegetative forms of the bacilli in the blood and tissues are quickly destroyed through the antagonistic influences that accompany decomposition of the carcass in the ground. They do not enter the spore-stage, for the reason that under the conditions of burial they are without the free access to oxygen that is all-essential to the process of spore-formation.

Of greater importance in preventing the occurrence of anthrax among herds is the method of preventive vaccination. Though all authorities are not agreed as to the practical benefits of this method, the results reported by certain reliable investigators are sufficient to warrant its being given a fair trial. Thus, for instance, Chamberlain reports as a re-

sult of experience with the method of preventive vaccination in France, for the twelve years ending with 1893, that the mortality from anthrax among 3,296,000 vaccinated sheep was 0.96 per cent., whereas prior to the introduction of vaccination it had been 10 per cent. During the same period 438,000 head of horned cattle (bovines) were vaccinated and 0.34 per cent. died of anthrax, the previous mortality from this disease among these animals having been 5 per cent. Favorable results have likewise been obtained in Hungary and in Russia.

The method has been practised on a smaller scale with satisfaction at the Agricultural Experiment Station at Newark, Del., in the neighboring counties of which anthrax has been mildly endemic for the past two or three years. The disease has never prevailed in this country to any great extent; it is, in fact, considered to be rare here. It is very common in South America, France, Russia, and Hungary. The method of preventive vaccination aims to induce a mild form of the disease by inoculating the animals with attenuated cultures of anthrax bacilli. Animals that have recovered from this mild form of anthrax are for a time, sufficiently long for all practical purposes, immune from the disease.

If upon slaughtering an animal it is found to have had anthrax, all spilled blood and all soiled articles should be at once disinfected. Over the blood that is spilled milk of lime (fluid whitewash) or 5 per cent. solution of chlorid of lime should be spread. Instruments should be boiled and the hands disinfected in 3 per cent. carbolic acid and washed thoroughly with soap and water.

The flesh of anthrax animals should never be used as food, even in the earliest stages of the disease. It should be buried or burned, or destroyed by quick-lime.

All hair and wool should be disinfected by steam. If this be impracticable it should be sorted moist, preferably moistened with a mild disinfectant. The ceiling, walls, and floors of sorting rooms should be frequently washed with strong carbolic-acid solution; the walls should be whitewashed from time to time. These rooms should be well ventilated, and

when the wools cannot be sorted in a moist state, this should be done under hoods provided with specially strong downward draughts for carrying off the dust.

Workmen should be impressed with the importance of personal cleanliness, daily bathing, the frequent dusting and washing of their clothing, and particularly the careful washing of the hands before partaking of food. The local secretions from malignant pustule, and the sputum and stools of persons suffering from internal anthrax are infectious, and should be disinfected. All bandages should be burned, and all instruments disinfected.

GLANDERS.

Definition, Cause, etc.—An infectious disease of horses, mules, and asses, communicable to man and caused by a specific micro-organism—the bacillus mallei.

The disease occurs in all countries and at all seasons. It attracts more attention in France, Belgium, Holland, Austria, Russia, and Germany than elsewhere. In both men and horses it is remarkable for its fatality.

The disease is known as glanders when the principal seat of its activity is the mucous membrane of the nostrils, and as *farcy* when it is confined to the subcutaneous [illegible], though both expressions may occur simultaneously. Glanders is characterized by the [illegible] of small [illegible] nodules [illegible] upon the mucous membrane of the upper air-passages [illegible]. These [illegible] and [illegible] discharge from the nostrils. [illegible] formation of [illegible] along the [illegible] glands. [illegible] suppuration.

Both glanders and [illegible]

the deposition of the specific causative agent upon the mucous membrane of the nares, the latter from its introduction into wounds of the skin.

In man glanders may assume either the acute or chronic form. Acute glanders is fatal, as a rule, in from one to two weeks; chronic glanders may exist for months without of necessity proving fatal.

In acute farcy in man the lymphatics are conspicuously involved, presenting along their course the cloudy nodular swellings known as "farcy buds." The local site of infection is acutely inflamed, presenting the characters of an acute phlegmon. The mortality from acute farcy is high. Death results in from two to three weeks.

Chronic farcy in man is characterized by local abscesses in the extremities. There is little lymphatic involvement. These abscesses break down and ulcerate. The disease often lasts for months, during which time there is frequent recurrence of the local suppurations. It is not necessarily fatal, unless acute glanders is engrafted upon it or pyemia supervenes.

The cause of the disease, *bacillus mallei*, as it is called, was discovered by Löffler and Schütz in 1882. It is a short, straight or slightly bent, pointed, irregularly staining, non-motile, non-spore-producing rod (Fig. 20) that is found in the secretions, in the pus, and in the characteristic granulomata of animals and man affected with the disease. It can be isolated in culture on the ordinary nutrient media, though gelatin is less adapted to this purpose than are the other media that can be kept at a higher temperature. Its growth is not especially characteristic, though on potato its development is simulated by but few, if any, other organisms. Here it grows as a moist, brownish, amber- or honey-colored layer that gradually assumes a deeper color as development proceeds.

It is destroyed in five minutes by a temperature of 55° C.; in five minutes by 5 per cent. carbolic acid and in two minutes by 1 : 1000 corrosive sublimate. It is killed in a few days by drying. It has been known to resist putrefaction for a long time. Boiling water instantly kills them—a prac-

tical point of value to be remembered in cleaning up the stalls of animals or the beds of men affected with the disease. Horses, asses, mules, lions, tigers, field-mice, guinea-pigs, and cats are susceptible to glanders. Rabbits are but slightly susceptible, and dogs and sheep less so. White mice, common gray mice, bovines, hogs, and rats are insusceptible. Man, as said, is susceptible to this variety of infection.

Beyond the appearance of the characteristic granulomata in the spleen, field-mice dead after subcutaneous inoculation with this organism present none of the lesions characteristic of the disease in the horse. The spleen is enlarged, and often

FIG. 20.—Bacillus mallei from artificial culture.

quite covered with tiny gray nodules having something the appearance of miliary tubercles. The pathological lesions and clinical course of the disease after subcutaneous inoculation of guinea-pigs are much more typical. The animal lives for from six to ten weeks, during which time the joints of the extremities become infiltrated, swollen, and stiff; the testicles become very much distended, often suppurating and breaking through the skin; and there is the characteristic mucopurulent discharge from the nostrils, secondary to ulceration of the nasal mucous membrane. The lungs, kidneys, liver, and spleen, especially the last, usually contain the minute,

gray nodules—the glanders granulomata. The bacillus of glanders may be recovered from all the lesions.

The most trustworthy diagnostic test for glanders is that recommended by Strauss. It consists in the introduction of a bit of the suspected culture or tissue into the peritoneum of a *male* guinea-pig. If the material used be from a case of glanders the animal's testicles begin to swell in about thirty hours, the skin over them becomes red and shining, and desquamation occurs; evidence of incipient suppuration is manifest, and there results a purulent orchitis that ultimately breaks through the skin.

The modern method used by most progressive veterinarians for the diagnosis of incipient glanders in horses is by the use of mallein. Mallein is the filtered product of growth of the glanders bacillus in fluid media. When injected into animals affected with the disease, even in so early a stage as to defy recognition by other methods of inspection, there results a striking constitutional reaction that is signalized by sudden but temporary rise of temperature; whereas a similar injection is sustained by healthy animals, or those not affected with glanders, without such a result.

Modes of Dissemination, Portals of Infection.—Glanders is commonly disseminated among animals through direct contact between the healthy and diseased, the source of infection being in most instances the discharges from the muzzle. It may be carried by flies, lice, ticks, and similar insects. Farcy may result from the extension of the disease from its primary site in the nose, along the lymphatics; or it may result primarily from infection of wounds of the hide.

In man the disease is the result of direct infection, glanders resulting from the deposition of infective matters upon the mucous membrane of the upper air-passages, and farcy from the infection of wounds of the skin.

In the ordinary sense of the word, the disease is not contagious, though it is not improbable that the air about the glanderous horse that is snorting or coughing contains the virus, and may cause the isease if inspired.

In man the disease is most frequently encountered in

grooms, horse-dealers, and others coming in close association with horses, mules, and asses.

Prophylaxis.—In neighborhoods that are free from the disease, all imported horses, mules, and donkeys should be quarantined until carefully inspected by a competent veterinary surgeon. All animals suffering from the disease should be killed. They should never be permitted to mingle in any way with healthy animals, or even kept in close proximity to them, after the diagnosis is established. Attendants who have been in charge of the diseased animals should not be permitted to handle the healthy ones until after thorough cleansing and disinfection of their clothing and hands.

Attendants should look with suspicion upon all horses having a discharge from the nose or corded nodules under the skin. They should guard carefully against infecting abrasions of the hands, however slight they may seem, with discharges from diseased horses.

Bandages, dressings, and instruments that have been used about animals or man affected with glanders are capable of carrying the infection, unless rendered harmless by thorough disinfection.

The stalls from which glanderous animals have been removed should be thoroughly cleansed with *boiling* water; the scrapings and sweepings should be scalded and burned. The droppings from such animals should be scalded or burned. The refuse of fodder should be scalded or burned.

The harness, particularly the bit, should be either thoroughly scalded, or soaked in 5 per cent. carbolic acid for a few hours, after which it should be scrubbed with soap and hot water, and dried before being used on a healthy animal.

The carcasses of dead animals should be deeply buried or burned.

ACTINOMYCOSIS.

Definition, Cause, etc.—A chronic infectious disease of cattle and man that results from the development within the tissues of the *actinomyces* or ray fungus.

Pathologically, the disease is characterized by the development in the tissues in which the fungus is growing—most frequently those of the tongue or lower jaw—of granulomatous masses that in some particulars suggest the tuberculous, in others the osteosarcomatous processes. In the more rapidly growing of these tumors suppuration, resulting in cavities and fistulous formations, may occur.

If the pus from a case of actinomycosis be spread upon a glass slide or allowed to flow down the inside of a test-tube, it will be seen by transmitted light to contain numerous small, white, yellowish, yellowish-green, or brownish points, easily discoverable to the naked eye and having somewhat the appearance of fine grains of sulphur or sand. If these be picked out, gently squeezed between a slide and cover-slip, and examined with a moderate power of the microscope, they will be found to consist of a felt-like mycelium of a roughly rosette shape. At the center the mass is coarsely granular and presents numerous oval and spherical spore- or coccus-like structures. About this center is a tolerably broad, irregular zone of straight, curved, and branched pear- or club-shaped radii.

From man these fungous tufts give the sensation, when squeezed under the cover-slip, of small particles of tallow or fatty tissue; whereas from animals they feel gritty, due to the deposition of lime-salts.

Staining is employed only for the detection of certain minute structural details that are not necessary for diagnosis. In unstained preparations the appearance of the tufts is characteristic. If the structure be obscured by a deposit of calcareous matter, this may readily be dissolved away with dilute acetic acid, without injury to the structure of the fungus.

It can be cultivated on practically all the ordinary nutrient media, especially glycerin agar-agar, coagulated blood-serum, and sterilized moistened bread-crumbs. In cultures the branching mycelia and the round or oval coccus- or spore-like bodies are formed, but the club-shaped bodies seen in the pus are less common, though they do occasionally present under these circumstances.

Notwithstanding the fact that several trustworthy investigators have reported positive results from the inoculation of animals with this fungus, Boström, who has contributed so liberally to our knowledge of the subject, still doubts that the disease has ever been really reproduced in that way. He claims that the tumefactions observed in the cases reported as successful were not due to a multiplication of the fungus, but were simply non-progressive points of proliferated tissue, by which the fungous masses used for inoculation have been encapsulated. The proof of its transmissibility by inoculation is as yet incomplete. The actinomyces fungus is a streptothrix.

Actinomycosis occurs in bovines, horses, and hogs. Its most common seat of development is the tongue and adjacent tissues of the jaws, particularly the lower jaw. It may occur in the lips, cheeks, palate, pharynx, nose, larynx, trachea, lungs, skin, and subcutaneous tissues.

From the frequency of its occurrence in the tongue and jaws, and from the induration, tumefaction, and stiffening that it occasions it is popularly spoken of as "lump-jaw," or "lumpy jaw," and "wooden tongue." It attacks cattle of all ages, and is usually considered to be incurable.

In man actinomycosis is a rare disease. When occurring it is most frequently seen as a disease of the lower jaw. The tumor rarely begins in the bone itself, but usually at its periphery, manifesting itself as a lump in the submaxillary, submental, or pretracheal region. Metastases from the primary growth are not uncommon. The disease may occur in the lungs, from inhalation of the fungus, resulting in pneumonic patches, suppuration, hemorrhage, and cavity-formation. The sputum of such cases contains the fungus. Clin-

ically, and in certain anatomical features, these cases are very suggestive of chronic pulmonary tuberculosis.

Invasion of the intestinal tract may also occur in man. In this expression of the disease small nodules of about the size of a pea are seen in the mucous membrane and submucous tissues of the gut. These soften, ulcerate, and either heal or,

FIG. 21.—Actinomyces fungus ("ray fungus"): left, as seen in tissues under low magnifying power; right, a fungus mass examined fresh under higher magnifying power.

as is more commonly the case, perforate into the peritoneum, bladder, or through the abdominal wall.

Dissemination, Portals of Infection.—There is no positive evidence that the disease is transmitted from animal to animal, or from animal to man, or *vice versâ*. It seems probable that both man and animals receive the virus from the same external source.

The belief is that the fungus is a parasite upon certain cereals, and that it gains access to the animal through wounds of the buccal mucous membranes, through abrasions of the skin, or by way of carious teeth. Barley is the grain that is viewed with most suspicion. Infection occurs most frequently, in all probability, during feeding, though some believe it to occur occasionally through inspired dust and through water containing the fungus or its spores.

Prophylaxis.—Since the disease is not readily transmitted from animal to animal, or animal to man, by either ordinary contact or by inoculation; and since nothing is positively known of the fungus outside the animal body (except in artificial culture), it is manifest that our knowledge is too limited to permit of the formation of trustworthy and rational prophylactic rules.

It is, of course, safer to regard subjects of the disease as dangerous and to isolate them, therefore; it is advisable to burn, scald, or otherwise disinfect articles polluted with the discharges from such animals or persons.

MADURA FOOT.

(*Fungus Disease of India; Mycetoma.*)

Because of the existence of certain points of resemblance between actinomycosis and Madura foot, it is proper to summarize the essential features of the latter disease at this place.

Mycetoma, Madura foot, or fungus disease of India, as the disease is called, is a chronic affection occurring in the foot, and occasionally in the hand, that is found endemically in many parts of India. It is not supposed to originate outside of India, though cases of the disease have been observed in Italy, Morocco, America, and elsewhere. In many instances these were imported.

It is characterized by local tumefactions of the foot or hand. It is usually found in the foot, and does not pass beyond the metatarsal articulation, though occasionally it is seen to include the leg and even reach as high up as the thigh. Anatomically this tumor in many respects suggests that resulting from the invasion of the tissues by the actinomyces fungus, though there is sufficient evidence to justify the opinion that the two diseases are etiologically distinct.

It originates in the toes or in the loose cellular tissues about the dorsum of the foot. It gradually involves the deeper structures, reaching quite to and affecting the bones. Numerous sinuses, which discharge a stinking watery pus, lead from the surface to the deeper structures. The affected part is very much enlarged, hard, tense, and painful. It never attacks both feet simultaneously. It is not communicable from person to person, and is not apparently auto-infective.

The hand is very much less frequently attacked than the foot. The agricultural classes are much more liable to it than are other classes of the community. When fatal, death results from marasmus. If the affected member be amputated sufficiently early, health is generally regained.

Etiology.—Two expressions of the disease occur—namely, the "white" and the "black" mycetoma. In both infections the tumors are characterized by the presence of numerous, minute granules about the size of a pin-head. In the white mycetoma these granules are white or yellowish in color; in the black mycetoma they are dark-brown or at times quite black in color. By microscopical and bacteriological methods these granules are found to consist of fungoid masses. The white mycetoma has been closely studied by Bristowe, Carter, Kanthack, Boyce and Surveyor, Adami, and others, and there is a general agreement of opinion that it is in many respects very like the actinomyces fungus. The fungus isolated by Vincent from white mycetoma is described by him as a mycetial streptothrix that grows readily at body-temperature on nutrient media containing sugar and glycerin. It develops especially well in vegetable infusions. It is not pathogenic in animals.

From the black mycetoma a fungus has been isolated by Bristowe, Hogg, Bassini, Kanthack, Boyce and Surveyor, Wright, and others, whose morphology, color, and cultural peculiarities distinguish it at once from that isolated from the white form of the disease. It is, therefore, likely that there are concerned in the production of this malady two distinct fungi.[1] The inoculation of animals with the fungus obtained

[1] An excellent description of the black mycetoma, as well as a review of

from the black mycetoma was, as in the case of that from the white mycetoma, negative in results. The two varieties of fungi do not appear together in the same case.

The disease is believed to occur in man through the access of the causative agents to wounds of the feet or hands.

It is very much more common among the Hindoos than among the Europeans or Indo-Europeans. Not a single case of the disease among Europeans or Indo-Europeans has been observed in India during the past forty years (Hirsch). It is most common between the ages of twenty and twenty-five years. It is extremely rare in the very young and in the very old. It is more common in males than in females.

SMALL-POX.

Definition, Cause, etc.—An acute, infectious, highly contagious disease that is characterized by an eruption upon the skin and exposed mucous surfaces. The eruption passes through the papular, vesicular, and pustular stages in turn, and finally heals under a scab. The disease is especially communicable during the convalescent period, when desquamation is actively in progress.

Though several micro-organisms, both of bacterial and protozoal nature, have been detected in the pathological lesions of small-pox, none of them have been proven to stand in causal relation to the disease. The cause of small-pox is as yet undiscovered.

Historical.—According to the exhaustive researches of Hirsch, the origin of the disease cannot definitely be made out, though the earliest records of it are found in India and Central Asia. The first medical literary contribution on small-pox is that of Rogers in the tenth century. Incon-

the literature on the subject, is given by Wright in the *Journal of Experimental Medi-* [illegible]. iii., p. 421. The illustrations in this article are of [illegible]

testable records of the disease in Europe date from the eleventh and twelfth centuries. It was introduced into North America by the Spaniards in the sixteenth century.

Small-pox has appeared among practically all peoples on the globe, and still appears with varying degrees of severity, more especially in localities where vaccination is not systematically practised. It attacks all ages, and is particularly fatal during the early years of life. Osler states that 86 per cent. of all deaths observed by him during the severe epidemic in Montreal in 1885 occurred in children under ten years old. Males and females are affected with practically equal frequency. Negro and other colored races seem to be more susceptible than are whites.

Excessive fatality has been observed to follow the first exposure of aboriginal races to this disease, such, for instance, as that seen among the early settlers, American Indians, and Mexicans after the importation of small-pox into this country by the Spaniards in the sixteenth century. It is much more prevalent during the cold than during the warm months of the year in temperate climates.

Dissemination.—In the majority of cases the disease appears to be directly transmitted from the sick to the well through the air. Persons unprotected by vaccination apparently contract the disease by simply breathing the air of the room in which the patient is confined. There is no evidence that the disease is transmitted by food or through wounds; neither is there any evidence to the contrary. Persons who have been in contact with small-pox patients, all articles used about the patient, such as body- and bed-clothing, eating-utensils, carpets, furniture, letters, etc., and vehicles in which the sick may have been transported, are capable of conveying the contagion.

The period of highest infectivity is believed to be during the stage of desquamation, when the morbific agent, of whatsoever nature it may be, is disseminated throughout the air with the fine particles of epidermis that the patient sheds. The disease is probably contagious sooner than this, but just how soon is not definitely determined.

Prophylaxis.—For the prevention and eradication of small-pox systematic (compulsory if need be) vaccination so overshadows in importance all other means as to make it the prophylactic measure *par excellence* against this pest. The isolation of the patient, the disinfection or destruction by burning of all clothing and other objects that have been in contact with him, the disinfection of his room, the anointing of his body with antiseptic oils during the dangerous stage of desquamation, etc., are precautions never to be ignored in efforts to prevent the spread of the disease; but they are as naught in efficiency as compared with the successful vaccination of all those with whom the small-pox patient or convalescent is likely to be in association (see and compare accompanying charts of Prussia and Austria, Charts 13 and 14.

To meet the demands of large centers of civilization in which sporadic cases and mild outbreaks of small-pox are from time to time occurring, there should be hospitals or lazarettos especially equipped for the management of acute, infectious diseases. These should be provided with proper facilities for isolating the cases, for disinfecting the clothing, and for frequent cleansing and disinfecting of the entire walls, ceilings, floors, and furniture of the wards or separate rooms. The personnel of such hospitals should comprise competent physicians, well versed in the laws of preventive medicine, and an adequate corps of nurses specially trained in the management of infectious diseases, all of whom should have been successfully vaccinated. Sporadic cases of small-pox should be sent to such hospitals at the earliest possible moment after the diagnosis is established. Hospitals for this purpose should be provided with special observation wards in which doubtful cases may be placed until the true nature of the disease is definitely made manifest.

For the welfare of the community at large, too much stress cannot be laid upon the importance of prompt notification of the existence of contagious disease. It is only through the full co-operation of physicians in these matters

CHART 13.—*Progress of small-pox in Prussia before and after the enforcement of general vaccination. Death-rate per 100,000 of population, 1846–1886.*

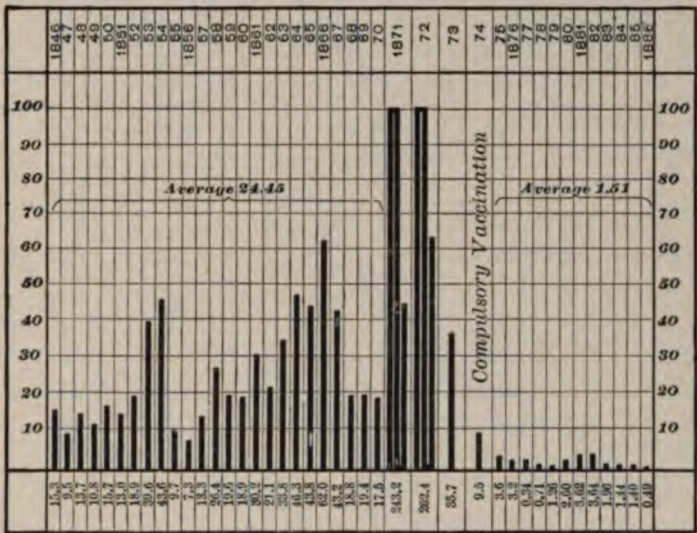
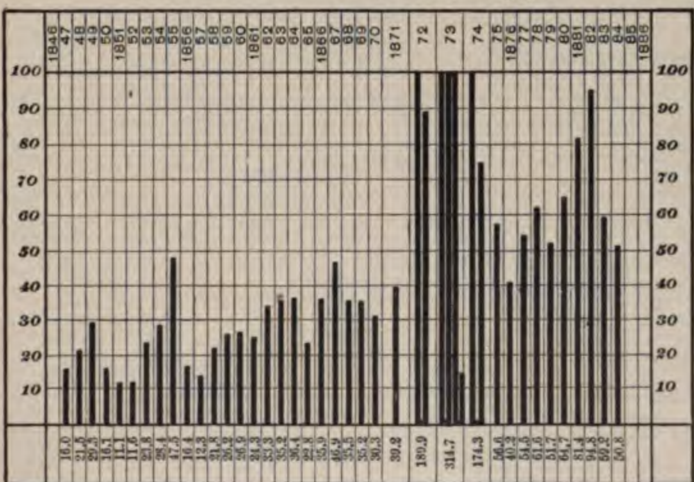


CHART 14.—*Progress of small-pox in Austria. No compulsory vaccination up to 1884. Death-rate per 100,000 of population.*



Charts 13 and 14 are after Schulz: *Impfung, Impfgeschäft und Impftechnik*, Berlin, 1891.

that the municipal health authorities are enabled to perform the functions of their office properly.

VARICELLA

(*Chicken-pox.*)

Definition, Cause, etc.—An acute, specific, febrile, disorder that is characterized by a peculiar vesicular eruption upon the skin. The cause is not known. It is rarely severe, and is one of the common diseases of childhood; it is especially seen in children under five years of age, though it may occur in older persons.

It prevails in the autumnal months. It is seen both as isolated cases and as epidemic outbreaks. It is not apparently related etiologically to small-pox, and an attack of chicken-pox in no way protects against small-pox, and *vice versâ*. Instances are recorded in which both diseases have occurred in the same individual within a short time of each other.

It is markedly contagious, but the channels through which it is especially transmitted are not definitely determined. The contagion appears to be air-borne, and also seems to be capable of being carried by fomites.

Prophylaxis.—The disease is contagious from its onset to its finish. The prophylactic measures that are adopted, when adopted at all, consist in the isolation of the patient, though, as a rule, the disease is regarded as so benign, and as a disease through which children are of necessity liable to pass, that few strict measures are adopted for the prevention of its spread.

The complications, or rather the unusual manifestations, of varicella are subjects more for works upon clinical medicine than for sketches of this character.

MEASLES.

Definition, Cause, etc.—An acute febrile disorder characterized by the occurrence of coryza and an eruption upon the skin of small red papules that ultimately coalesce into irregularly round or crescentic blotches.

Measles is one of the most, if not the most, contagious of the acute exanthemata. Its cause has not yet been determined.

It is a disease of the first five years of childhood, though it is also occasionally observed in adults. The rarity of measles in adults is probably to be explained through the fact that practically all children pass through the disease, and one attack usually protects against subsequent infection, though this is not always the case, as instances are recorded in which more than one occurrence of the disease has been observed in the same individual. It is endemic in all civilized countries and occasionally breaks out in epidemic form. It is a disease of late autumn and early spring.

It is directly communicable from the sick to the well; the secretions from the catarrhal surfaces and the exfoliated epidermis are capable of infection, and the disease may be carried by fomites and by persons.

As in the case of varicella, vigorous efforts are rarely made to prevent the spread of measles. It is so eminently contagious that the usual efforts are considered of but little avail. The patient should be isolated, and only the nurse and physician should have access to the sick-room. The napkins, towels, dishes, bed- and body-clothing should be disinfected before they are permitted to be taken from the room. After recovery the room should be thoroughly disinfected and cleaned, and well aired.

Rubeola (*Rötheln* or *German measles*) partakes of certain of the characteristics of both measles and scarlatina, though immunity to it is not conferred by an attack of either of these diseases. Its cause is not known. It is considered a distinct, specific, febrile disorder. It is characterized by an eruption. It is communicable by direct contact between the

sick and the well. It is less contagious than measles. It is more common in youth than in childhood. It often occurs in epidemic form.

In other respects, what has been said for measles applies also to rubeola, except perhaps that its spread is more readily controlled than is that of measles.

SCARLET FEVER.

Definition, Cause, etc.—An acute, specific fever characterized by the occurrence of erythematous rash upon the skin, and accompanied by angina of varying degrees of severity. Its cause is not known. The various bacteria and protozoa that have been described as occurring in these cases have not been proved to stand in causal relation to them.

Because of the constant presence of streptococci in the angina that is associated with scarlatina, and because of the occasional detection of this organism in the internal viscera as well, it is held by some that the streptococcus found stands in causal relation to the malady. This opinion is not, however, generally accepted, principally for the reasons that the streptococci discovered do not differ from the ordinary pyogenic streptococcus, and that the disease is in all respects different from the usual results of infection by this organism. It has been suggested that the clinical manifestations of the disease as well as the anatomical lesions, except those in the throat, are the result of absorption of toxins produced by the streptococci located in the diseased tonsils, and that the disease is not necessarily a result of general systemic infection ; this view also is not generally accepted. In the present state of our knowledge it can only be said that the exciting cause of scarlet fever is as yet unknown, and that up to date there have not been any suggestions upon this point that have met with general acceptance.

It is contagious, though less so than measles. It occurs

both sporadically and as epidemic outbreaks. It is most common during the first ten years of life, though it is also seen in adults. It is not very common in children under one year of age. The accompanying table (Table X.) (from Goodall

TABLE X.—*Scarlatina at the Hospitals of the Metropolitan Asylum's Board, London. Arranged according to ages (Goodall and Washbourn*[1]*)*:

	Cases admitted.	Deaths.	Fatality per cent.
Under 5 years	23,072	4052	17.6
5 to 10 "	33,647	1789	5.3
10 to 15 "	14,399	345	2.4
15 to 20 "	5,319	139	2.6
20 to 25 "	2,509	65	2.6
25 to 30 "	1,215	38	3.1
30 to 35 "	665	31	4.7
35 to 40 "	281	16	5.7
40 years and upward	243	15	6.2
Total	81,350	6490	8.0

and Washbourn) strikingly illustrates these points. It is a disease of autumn and winter (see diagram in Section I., under the heading of Predisposing Influence of Season). It is known among all peoples in all countries.

In mild outbreaks the fatality varies from 4.2 to 10 per cent., while in severe epidemics it often reaches 15 and 20 per cent. of those affected.

Dissemination.—Scarlet fever is probably contagious at all periods, but it appears to be especially so during the stage of desquamation. The morbific agent, whatever it may be, is very tenacious of life and pathogenic powers, and may cling to clothing, furniture, and the like for very long periods, retaining its power to reproduce the disease under favorable circumstances.

Physicians, nurses and attendants, members of the family, and fomites may carry the disease. Contagion may also occur directly through the air of the sick-room, and this is perhaps the commonest mode of transmission, especially when the air is laden with the fine dust-like particles of epidermis shed by

[1] *Infectious Diseases*, by Goodall and Washbourn, Philadelphia, 1896.

the patient during the stage of desquamation. In the earliest stages—*i. e.*, before the development of the eruption—it seems to be less contagious than later. There is no evidence that the disease is conveyed by water. There are a number of instances in which it has been carried and more or less widely disseminated by infected milk. By some writers the milk of cows affected with streptococcus inflammation of the udder is believed to be capable of causing the disease in human beings who use it.

The angina of scarlet fever, when uncomplicated by diphtheria, is caused by the ordinary *streptococcus pyogenes;* at least this pathogenic species is so constantly present in the condition, and in such numbers and often unassociated with other disease-producing bacteria, that this opinion is reasonably justifiable.

Diphtheria may be engrafted upon scarlatina, in which event *bacillus diphtheriæ* is found in the fauces, usually associated with streptococci.

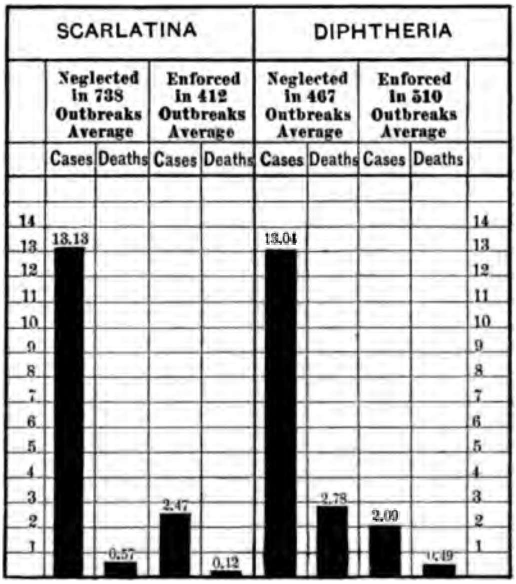
The angina of uncomplicated scarlatina is not, therefore, etiologically identical with the pseudomembranous inflammation of the fauces that characterizes true diphtheria, though both clinically and anatomically it may present a number of features in common with it.

Prophylaxis.—The patient should be isolated in a room as scantily and simply furnished as circumstances will permit. The accompanying diagram illustrates what has been done in Michigan by enforced isolation of cases of both scarlatina and diphtheria (Chart 15).

Because of the ease with which the disease may be carried, only the physician, nurse, or immediate attendant should have access to the room; and because of the tenacity to life possessed by the scarlatina virus, great care should be given to the disinfection (by boiling water, carbolic-acid solution or chlorid-of-lime solution) of all articles before they are permitted to leave the room.

The entire surface of the body of the patient should be kept anointed with an antiseptic oil or ointment to prevent the escape of particles of epidermis into the air. These pre-

CHART 15.—*Showing influence of isolation and disinfection upon scarlatina and diphtheria in Michigan during the eight years 1887 to 1894.*



From *Report of the Michigan State Board of Health*, 1897.

cautions should be observed until desquamation is *complete*. After removal of the patient the room should be carefully disinfected with formaldehyde gas and the bedding subsequently subjected to steam sterilization, or the entire wall-surfaces, including ceiling and floor, all furniture, mantles, etc., should be thoroughly wiped with a cloth or sponge soaked in a 3 per cent. carbolic-acid or 1 : 1000 corrosive-sublimate solution; the carpets, hangings (if such are present), the bed-clothing, mattress, etc., should be disinfected by steam. These should be enveloped in sheets soaked in either of the above solutions before being taken from the room to the disinfecting station.

The bedstead and room should then be scrubbed with soap and water, the windows opened, the door locked, and the room thoroughly aired for several days.

WHOOPING COUGH.

(*Pertussis.*)

Definition, Cause, etc.—A contagious disease characterized by a peculiar spasmodic cough that ends with a "whoop" (inspiratory) from which the disease gets its designation.

The investigations that have been made upon whooping cough with the hope of discovering its cause have been discordant in their results. Protozoa, diplococci, and bacilli have from time to time been found microscopically and been isolated by bacteriological methods from cases of this disease by different observers. It is impossible to state definitely which, if any, of these several micro-organisms plays the etiological rôle in the disease; for by the employment of none of them has it been possible to reproduce the disease, as it is seen in man, in lower animals. The most recent, and in many ways the most satisfactory, of these studies is that

of Koplic,[1] who detected in 13 out of a series of 16 cases a bacillus, which he thinks may reasonably be regarded as playing an important part in the causation of the disease. In the uncomplicated cases this bacillus was often the only organism present. It was readily isolated in pure culture through the employment of coagulated hydrocele fluid under anaërobic conditions. Inoculations of animals with this micro-organism resulted usually in local or general suppurative infections, and in no instances did he succeed in getting a condition that in any way suggested the disease as it occurred in man.

Koplic considers it as reasonably certain that the organism found by him is identical with that found and described by Afanassjew in 1887.

"Probably the lungs are the seat of invasion, and the catarrhal stage represents the period of growth of the micro-organism, the paroxysmal attacks being caused by the absorbed toxins, and being comparable to the convulsions of tetanus" (Goodall and Washbourn). It is seen both sporadically and as outbreaks of varying extent.

It is a disease of childhood, though no age is exempt from it. It is more frequent, and also more serious, in cold than in warm climates. According to the statistics of Hirsch, the season of the year seems to be of little influence upon the prevalence, though it is usually considered, in this latitude, to be a disease of winter and spring.

The fatality of this disease varies considerably in different epidemics, and depends largely upon the secondary complications. It is much more fatal in negroes than in white children, and in females than in males. It is a serious malady, and in England ranks next to diarrhea as the cause of mortality among young children, though the last United States census shows it to be hardly so fatal in this country. A single attack protects against recurrence of the disease in the majority of cases.

The disease is disseminated directly from the sick to the well individual through the breath and through matters ex-

[1] *Centralbl. für Bakteriologie und Parasitenkunde*, 1897, Bd. xxii., S. 222.

truded while coughing, though there is reason to believe that its virus may be harbored about rooms, in clothing, and upon furniture. It is contagious from the onset until the "whoop" has disappeared.

Prophylaxis.—The serious nature of whooping cough, especially when occurring in very young and feeble children, calls for more attention to the prevention of its spread than it ordinarily gets.

The patient should be carefully isolated for as long as the paroxysmal cough exists, for during this entire period they are capable of disseminating the disease. It is hardly necessary, therefore, to state that children with whooping cough should never be permitted to attend school. All handkerchiefs, towels, napkins, eating-utensils, etc., used by the patient should be disinfected before being taken from the apartment in which the patient is isolated. The room in which the patient has been isolated should be properly disinfected after it has been vacated; during its occupancy all horizontal surfaces should be wiped from time to time with a cloth moistened in a 3 per cent. carbolic-acid solution. When the weather permits, the patient should have the freest possible access to fresh air, sunlight, and moderate outdoor exercise.

MUMPS.

Definition, Cause, etc.—An acute, specific infection characterized by swelling of the parotid and other salivary glands. Its cause is not as yet known. Both bacilli and micrococci have been discovered in the swollen glands, but they are not shown to stand in causal relation to the disease.

It is endemic in all countries. It frequently occurs as local epidemics. It is most prevalent in autumn and spring. It occurs between the ages of five and fifteen years, less commonly in older persons, and rarely in children under one

year. It is somewhat more common in boys than in girls. It is markedly contagious and spreads by direct contact. The breath and secretions from the mouth seem capable of causing infection. It is not conspicuously disseminated through the agency of persons or by fomites.

Its period of incubation is reckoned as from fourteen to twenty-five days. The patient is considered infectious, especially infectious, during the period of active inflammation of the salivary glands.

These patients should be isolated for at least three weeks from the onset of the disease.

MALARIAL FEVER.

Definition, Cause, etc.—The term malarial fever is used generically to indicate a group of febrile disorders that result from the invasion of the body by a specific micro-organism —viz., *plasmodium malariæ*—discovered by Laveran in 1880. Malarial fevers are therefore infectious, though they are not contagious.

These fevers may be divided clinically into two primary groups—viz., the intermittent and the remittent or continued fevers, though etiologically they are all dependent upon the same or closely allied parasites.

The intermittent malarial fevers are characterized by the periodic occurrence or paroxysms, consisting of chills, fever, and sweating, in the order named, and by the disappearance of symptoms during the interval between the paroxysms. According to the length, in days, of the interval between paroxysms, the commoner manifestations of the intermittent fevers are designated as quotidian—*i. e.*, those occurring every day; tertian, occurring every other day; quartan, occurring after an interval of two days.

In the remittent or continued types of the fever the characteristic, periodic occurrence is often lost. The fever may

be continuously above normal, and there may be regular or irregular remissions.

Pernicious malarial fever is a rare manifestation of the disease in this latitude. It represents a condition in which the body is more or less suddenly overwhelmed by the malarial poison. It is often fatal. Three clinical forms of pernicious malarial fever are recognizable—viz., the comatose, in which the symptoms are principally cerebral; the hemorrhagic, characterized by hemorrhage from the mucous membranes and from the kidneys; and the algid form, in which the most conspicuous symptom is extreme prostration, with little or no tendency to rise in temperature. The true nature of these symptoms is frequently difficult of recognition by the

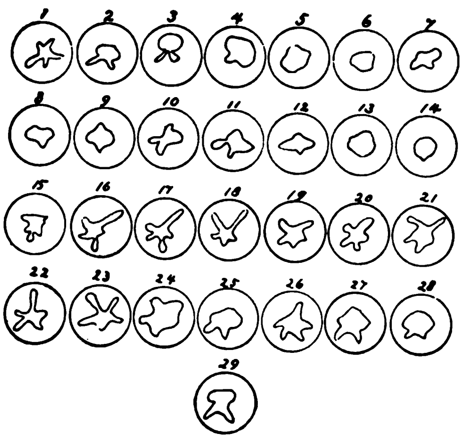


FIG. 22.—Diagrammatic representation of the succession of shapes assumed by an actively amœboid intracorpuscular plasmodium during the course of five minutes (author's observations).

ordinary clinical procedures. This difficulty is, however, easily cleared away by microscopical examination of the blood for the causative parasite.

The plasmodium of malaria is an animal parasite belonging to the protozoa—*i. e.*, it consists of simple, undifferentiated protoplasm. Because of its presence in the blood it is often referred to as "hematozoon." In the blood of persons suffering from the same type and in the blood of those suffering

from different types of malarial fever, a number of different forms or developmental phases of the parasite may be observed.

It is hardly appropriate in a sketch of this character to describe in detail all the various forms that are assumed by the plasmodium of malaria, or to enter into a full description of the developmental steps through which it passes in the several forms of fever in which its life history has been carefully studied. It will suffice, for purposes of illustration, to follow here the development of the parasite in one of the typical clinical manifestations of intermittent fever, and to refer the reader to special monographs for full details of the subject.[1] The commonest of the intermittent fevers encountered in this vicinity is the tertian type—*i. e.*, that in which the paroxysms occur on each alternate day.

If one examine the fresh unstained blood of a patient suffering from tertian intermittent fever, during the latter part of or shortly after the paroxysm, one will observe that many of the red blood-corpuscles contain within them small, round, pale bodies that occupy from about a sixth to a fifth of the corpuscle in which they are located (1 in Fig. 23). They are actively amœboid and, as a result, the pseudopedia that they are constantly throwing out, cause them to assume a variety of shapes that follow upon one another in quick succession (see 2, 3, 4, 5, Fig. 23). As time passes on, these small bodies increase in size; gradually reddish-brown pigment-granules begin to appear within them. These are at first very minute. They vary in shape, and are in active, oscillating motion. The organism gradually increases in size, and the pigment becomes more manifest. The corpuscle in which the organism is located becomes paler, and, when compared with its normal neighbors, is seen to have appreciably increased in size. With further growth of the

[1] The most complete and satisfactory treatment of this subject that it has been my good fortune to encounter is contained in "The Malarial Fevers of Baltimore, etc.," by Thayer and Hewetson, *Johns Hopkins Hospital Reports*, 1895, vol. v. See also—Lectures on the Malarial Fevers—by Wm. Sidney Thayer, M. D., published by Appleton & Co., N. Y., 1897.

organism its amœboid movement becomes less apparent. The amount of pigment increases; it continues its active dancing motion, and is now seen to be irregularly arranged around the periphery of the organism (6 in Fig. 23). Before the end of forty-eight hours the organism has usually completely filled its enveloping red blood-corpuscle. The pigment is very much increased in amount, and surrounding the organism is a thin rim, the remains of the invaded corpuscle. Sometimes all indication of red corpuscle disappears. When this stage is reached, the hitherto actively oscillating pigment becomes motionless, or nearly so, and tends to collect near the center either as a single black or as a mass of

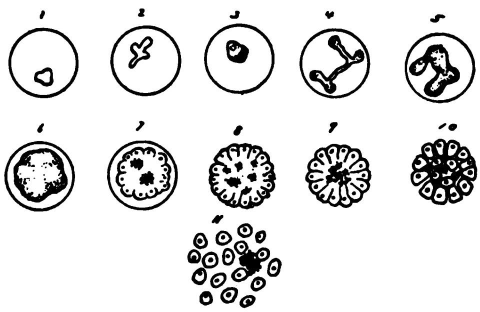


FIG. 23.—Some of the principal forms assumed by the plasmodium of tertian fever in the course of its cycle of development (after Thayer and Hewetson).

dark, almost black granules. The substance of the organism now becomes finely granular and somewhat more refractive. Indistinct radial striations make their appearance at the periphery of the body; these grow more and more distinct, till finally the central pigment-mass is surrounded by from 12 to 20 or more pear-shaped segments that give to the whole a rosette-like appearance (7, 8, 9, 10 in Fig. 23). Each segment presents a small refractive central spot. A little later the central pigment-clump is seen to be surrounded by a group of completely separated, round, hyaline bodies similar in all respects to those seen in the corpuscles at the beginning of the observation (11 in Fig. 23)—*i. e.*, during the latter part of, or shortly after, the preceding paroxysm; at

this time also one begins to notice the appearance of similar, small, hyaline bodies in some of the red corpuscles. "We have thus a very suggestive chain of evidence in favor of the view that this is a reproductive process; that these hyaline segments resulting from the division of the organism are identical with the fresh hyaline forms that appear in the red cells."[1] It is highly probable that these segments represent a brood of young parasites which, in time, invade a fresh set of corpuscles and undergo the cycle of development and reproduction described for their progenitors. The final developmental phase of the parasite—viz., segmentation—is always coincident with or a little antecedent to the occurrence of a characteristic paroxysm.

Based upon these observations Golgi formulated the following laws: "Each febrile paroxysm is closely connected with the cycle of development of a generation of parasites: the beginning of each paroxysm corresponds to the maturation of a generation of parasites: the severity of the paroxysm is, in general, proportional to the number of the parasites which are found in the blood."

Opinion as to the actual cause of the characteristic paroxysm is divided. Golgi believes it to be due to the invasion of the red blood-corpuscles by the brood of young parasites that have resulted from the segmentation of the mature organism, while Antolisei considers the chill to be due to the actual segmentation of the fully-grown plasmodia, rather than to the invasion of the corpuscles. Baccelli suggests the toxic origin of the paroxysm, and advances the idea (now acceptable to the majority of investigators) that the phenomenon results from the influence upon the vasomotor centers of a poison, either liberated at the time of segmentation by the parasite or occurring as a product from the red blood-corpuscles that have been destroyed.

In addition to the small and large amœboid and pigmented forms that are regularly observed in the developmental cycle of the parasite, in tertian, quartan, and æstivo-autumnal fevers, other forms are encountered. The most conspicuous of these

[1] The above description is condensed from Thayer and Hewetson, *loc. cit.*

are the flagellated varieties and the "crescents" (Fig. 24). The former are seen in one or all varieties of intermittent fever, usually at or about the period of the paroxysm; and in the æstivo-autumnal fever Thayer and Hewetson frequently detected them in the blood-specimens long after all febrile symptoms had disappeared. They are easily recognized, consisting of a pale, pigmented body often as large as, sometimes larger (according to circumstances) than a red corpuscle, which is provided with one or more slender, thread-like flagella that lash about in a very active manner. One or

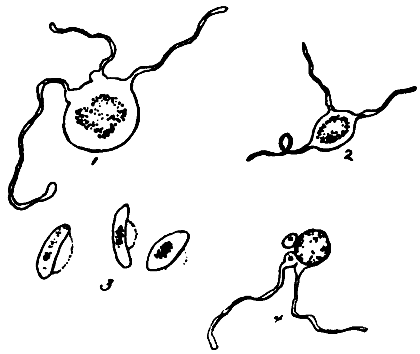


FIG. 24.—Crescentic and flagellated forms of plasmodium malariæ: 1, flagellated form of tertian fever; 2, flagellated form of quartan fever; 3, crescents, and 4, flagellated form of æstivo-autumnal fever (after Thayer and Hewetson).

more flagella may become detached and lead an independent existence. The pigment-granules contained within the body are in active dancing motion, and an amœboid movement of the body can usually be made out. For reasons too numerous to discuss here, the flagellated forms are regarded by many to be degenerative forms of the parasite, while, on the other hand, others consider them to represent the organism in its highest stage of development.

In his paper "On the Hematozoon Infection of Birds,"[1] MacCallum describes an observation of fundamental importance that he has made upon the developing parasites in the blood of crows. He has observed that in a particular stage

[1] *Jour. of Experimental Medicine*, 1898, vol. iii., p. 117.

of development two forms of the organism may be simultaneously encountered:—one a motionless pigmented, the other a hyaline, actively motile, flagellated body. After a time the flagella become detached from the latter and one of them may readily be seen to penetrate the motionless granular form, while the remaining flagella from the same parent organism disappear. He regards this as a sexual phenomenon and suggests the probability of the flagellated malarial parasite of man having a similar significance.

The "crescents," as their name implies, are crescentic in shape. They are somewhat refractive bodies that are usually marked about the center with an irregular clump or ring of pigment-granules. They may lie free, or have attached to them what appears to be the remains of a red blood-corpuscle. They are encountered only in the protracted forms of malarial poisoning—*i. e.*, after the second week in the æstivo-autumnal fever, in the malarial remittent fevers, and in the cachectic victims of chronic malaria. Their significance is not definitely understood.

In the present state of our knowledge it is difficult to decide whether all the various forms of the parasite, as seen in the blood in the different expressions of malarial infection, represent developmental stages of one and the same polymorphic organism, or whether some of them are phases of one and others of another variety, or of other varieties, of the closely-allied species of protozoa that are all capable of inducing symptoms characteristic of malarial fever. Certain it is, however, that among the most competent students of these fevers there is practically an agreement of opinion that at least three distinct varieties of the parasite are concerned in producing the three commonest manifestations of malarial infection—viz., the tertian, the quartan, and the æstivo-autumnal fevers—and that during the course of these fevers it is possible to detect a pretty regular series of developmental phases through which each of the varieties of the parasite passes, beginning with the small, simple, intra-corpuscular body, and ending with one mode of segmentation (reproduction) or another. The parasite has not been

observed outside the body, and we have not as yet sufficient data on which to base a positive statement as to all the portals through which it gains entrance to the body.

Geographical Distribution.—The malarial fevers have a very wide distribution. They vary markedly in the degree of their intensity in different localities.

It may in general be said that the most severe manifestations are seen in tropical countries; and that as we pass from these regions of greatest malignancy into the temperate zones, the centers of endemicity become less frequent and the character of the disease less virulent.

The disease is seen in its greatest severity upon the west coast of Africa; in Algeria; along the coasts of India, China, and Persia; in Chili, Peru, and Brazil; on the eastern coasts of Central America and Mexico; and along the shores of the southern United States that border upon the Gulf of Mexico.

The principal malarial regions of Europe are southern Russia in the region of the Caspian Sea; southern Germany along the lower Rhine and Danube; the west coast and a large part of northern Italy; southeastern France, especially in the valleys of the Loire and Rhone; and the southwest coast of Portugal.

In isolated areas the disease is seen in northern, northwestern, and western Europe, though to a much less extent than in the other localities named. It is rare in England, prevailing to only a limited degree near the east coast.

In this country the disease is much more frequent, and its manifestations are much more severe in parts of the southern and southwestern States than elsewhere. In the Middle States there are a number of endemic centers, while as we pass into the northern and New England States these become much reduced in number. In the northwestern States and in northwestern Canada the disease is almost unknown. In late years both the frequency and the severity of malaria in this latitude have undergone a very great modification, and many localities in which the disease was formerly endemic have become practically free from it.

The remittent and pernicious forms of malaria are most frequently encountered in tropical and subtropical regions. The intermittent fevers, especially the quotidian and the quartan, while also common in the warmer localities, are widespread in their distribution, being frequently encountered in temperate latitudes. The commonest, and at the same time the least malignant, form of malarial fever that ordinarily prevails in the higher latitudes, is the tertian remittent fever.

Conditions that Influence the Development of the Malarial Virus.—The designations "paludism," "paludial," and "marsh fever," by which malarial fever is variously known, indicate the close relation that it is believed to have to marshy and swampy localities.

Notwithstanding the fact that malaria is known to occur in localities that are not marshy, and on the other hand to be often absent from those that are low-lying and swampy, it must be admitted that it is much more frequent and severe in partly inundated, badly drained lands than in localities of higher altitude, where the drainage of the soil is more complete.

A certain amount of water in the soil appears to be an essential for the development of the malarial virus.

Marshes that are alternately flooded and imperfectly drained of water offer conditions that are most favorable to the occurrence of malaria. A malarious marsh if completely and permanently flooded may become innocuous; but it will usually resume its dangerous character if the water-level is permitted to fall sufficiently low to expose its earthy surface.

Many marshes that are periodically flooded by salt water are the breeding-grounds of the most malignant forms of malarial poisons, while others, even when located in the tropics, are free from such danger.

It is a notorious fact that malarious swamps may be, and often have been, robbed of their noxious qualities by proper drainage. Where adequate arrangements for drainage have not been provided, malaria has been known to follow upon the artificial irrigation of arid lands.

The soil conditions that are regarded as especially favorable to the development of malaria are excess of moisture and of decaying vegetable matters, such as obtain in low-lying, marshy places, in the broad alluvial deltas of great rivers, and along the valleys of smaller steams, particularly where these are located in the warmer latitudes.

"By far the largest proportion of cases of malarial fevers originates, not from exposure to the air of marshes, but from the malaria given off from damp bottom lands, from the deltas of rivers subject to annual overflow, from the margins of streams when these are exposed during the dry season, and especially from alluvial plains under cultivation. This naturally results from the necessary exposure in these situations, and from the fact that malarious marshes are avoided as far as possible" (Sternberg).

The geological condition, *per se*, of a soil does not appear to play an important part in the production of the virus, nor does its locality seem in all instances to be an essential factor, for the disease has been observed in elevated mountainous districts and in low-lying sandy plains.

Throughout the malarious zones it has generally been observed that the breaking up of virgin lands has, as a rule, resulted in the appearance of malaria in the immediate vicinity, and that often by prolonged cultivation of such soils the disease ultimately becomes less frequent and severe, and may finally disappear altogether from the neighborhood.

While the above-mentioned conditions of the soil are in the main those usually regarded as most favorable to the existence of malaria, still they are not infallible indications. In fact, one cannot certainly predict from physical conditions alone whether this or that locality is healthy or not as regards malarial fever. On this point Osler expresses the opinion that the only safe guide is the existence of the disease among people residing in the immediate vicinity.

The **influence of rainfall** depends upon circumstances. If by an excess of rainfall the low-lying malarious lands become completely flooded, the disease may, in consequence, be temporarily arrested. An impervious surface-soil that does

not readily become saturated, but rather favors the rapid shedding of rain-water, is not regarded as favorable to the development of the disease. A permeable, shallow surface-soil overlying an impervious stratum may favor the growth of the virus under the conditions of very moderate rainfall.

As a rule, dry, porous, sandy or gravelly soils are less frequently favorable to malaria than those that more readily retain moisture and are constantly partly saturated with water.

Influence of Season.—In this latitude malaria appears most conspicuously in spring and autumn, and least of all in winter—*i. e.*, it occurs in those seasons that are characterized on one hand by beginning growth of vegetation, and on the other by its death and decay.

A moderately high temperature appears to be an essential factor to the development of the malarial virus. In both tropical and temperate regions the fever is more prevalent after prolonged hot spells. According to Wood and to Drake, malaria is rarely developed at a temperature lower than 60° F.

As a rule, it becomes less frequent and less malignant as we recede from the thermal conditions that obtain in the tropics to those of higher latitudes.

Influence of Air-currents.—There is a widespread conviction that the malarious virus may be carried by winds. In malarious regions near the coast the land-breezes, especially if they traverse neighboring marshes, are poisonous, while the sea-breezes are not. Many localities that may be otherwise highly suspicious, but which are continuously wind-swept, are often free from the disease. This is especially true for many of the tropical islands of the Gulf of Mexico and the Pacific Ocean.

Under ordinary circumstances, the virus of malaria is not believed to ascend very high above the ground. In malarious districts it is a common observation that the dwellers in high places, in the upper stories of houses, etc., may escape the disease, while those on the ground-floor contract it.

When regularly seen in places of high altitude it is not usually due to its ascent with currents of air from the low

lands, but rather to its development under local conditions that may exist at the high level. There is, however, evidence to indicate the possibility of its being wafted to high altitudes by very strong winds blowing along narrow, insalubrious valleys and up mountain sides.

Modes and Portals of Infection.—Since the malarial parasite has not been observed outside the body, it is impossible to speak with certainty as to all the modes of its entry into the system.

The ideas hitherto held with regard to this point are that infection may occur through the alimentary and respiratory tracts, and through small wounds of the skin, such, for instance, as those resulting from the bites of insects, especially mosquitoes. Though these views are based upon what are believed to be pretty trustworthy observations, still, in the light of experiment, they appear to be of very different degrees of importance. As a result of modern investigations it seems probable that, of the three portals mentioned, skin-wounds made by insects are the most frequent and the alimentary tract the least frequent channels through which the organism gains access to the blood.

The investigations of a number of the Italian observers (Celli, Marino, Zeri, Grassi, and Feletti) demonstrate that it is practically impossible to cause malarial infection by way of the alimentary tract. In these experiments healthy persons were permitted to drink of water from malarious marshes; enemata of similar waters were given to other persons; and, in the experiments of Grassi and Feletti, healthy persons were allowed to drink of blood from malarial patients, but in no instance did malaria result. We feel justified, therefore, in concluding that either this is a very unusual mode of infection, or that some important factor that is present in the course of natural infection was inadvertently omitted from the experiments.

There is a very general impression that infection can occur through the respiratory tract, though as yet we have no proof of it, and the results of experiment leave the question still in a very unsatisfactory state.

With regard to infection through wounds of the skin, Bignami[1] holds the opinion that this is the most frequent channel through which the disease is contracted, and he advances very strong arguments in support of the view that infection is usually due to the bites of mosquitoes, much in the same way that the Texas fever of cattle originates with and is disseminated by the bites of infected ticks. Among many forcible arguments in support of his hypothesis, Bignami states that in the highly malarious regions of Italy the precautions taken by the natives against malarial fever are always equally effective against mosquitoes. These individuals in some localities sleep in houses elevated upon stakes or piles to a distance of 12 to 15 feet above the ground. They avoid going out at night. They are careful not to sleep in the open air at any time day or night. They close their windows with badly fitting shutters, which impede the ingress of insects but not of air. They take great care of their mosquito curtain, making it of very close net, under which they sleep, thoroughly shut in, notwithstanding the great heat. Bignami ascribes the limited vertical ascent of the malarial virus in the air to the fact that mosquitoes as a rule do not fly very high above the ground. In view of the fact that the only method by which genuine malaria has been produced experimentally in man is that of inoculation with the blood of malarial patients, and that this has repeatedly been done, the opinion advanced by Bignami acquires considerable importance. In a discussion of this subject Laveran also expresses the belief that the disease is much more often contracted through the bites of insects, particularly mosquitoes, than in any other way.[2]

The whole question, however, of mode of infection in malaria is as yet in a somewhat unsatisfactory state.

Prophylaxis.—From the foregoing the measures of prevention may readily be summarized as follows:

Efficient drainage of damp soils.

[1] "Hypothesis as to the Life History of the Malarial Parasite outside the Human Body," *Lancet*, Nov. 14 and 21, 1896.

[2] "Comment prend—on le paludisme," *Revue d'Hygiene*, 1896, p. 1049.

Place of residence as high above and as far removed from low-lying districts as circumstances will permit.

Avoid sleeping in the open air in malarious districts during either the day or night.

Adequate protection against the bites of insects, especially of mosquitoes.

Though experimental evidence contra-indicates its necessity, both food and water should be cooked in malarious regions.

While in malarious regions it is a valuable precaution to take from 4 to 5 grains of quinine daily on rising in the morning.

NOTE 1.—From a series of experiments, the results of which have been recently published (*Centralbl. für Bakteriologie*, 1897, Bd. xxi., S. 49), Celli and Santeri draw the conclusion that the period of incubation of malarial infection may be very much prolonged through the injection into the individual of the blood-serum from certain animals that are naturally immune from malaria. This observation, while of scientific interest, can hardly be regarded as of very great practical importance, since we already possess, in quinine, a body that, in both its therapeutic and prophylactic employment, is known to be a specific, in the full sense of the word, against malaria.

NOTE 2.—It is my pleasant duty to acknowledge the assistance that I have received, in the preparation of this sketch, from the exhaustive monograph of Thayer and Hewetson, already referred to.

YELLOW FEVER.

Definition.—An acute, specific, febrile disease of tropical and subtropical climates that is characterized by jaundice, hemorrhages from the mucous membranes, vomiting of dark or black, grumous matters (the so-called "black vomit") and albuminuria. It occurs endemically in certain districts of the tropics, and at times spreads epidemically over regions beyond the zone of endemicity. Though its cause is not known, it is obviously an infectious disease. It is not regarded as contagious—*i. e.*, directly transmissible from the sick to the well.

Etiology.—Notwithstanding the fact that a good deal has been said and written during the past two years on the etiology of this disease, there are still good grounds for believing that the exciting cause of yellow fever has not yet been discovered.

The contributions upon the subject that have received the most serious consideration are those of Sternberg and of Sanarelli.

In 1888 Sternberg called attention to the micro-organism, designated by him as "*bacillus X*," that he had found in about 50 per cent. of fresh yellow-fever cadavers examined by him. He did not certainly regard it as the cause of the disease, though, because of its pathogenic properties and its presence in only yellow fever, he thought it might possibly be, in some way or other, concerned in its etiology.

In 1897 Sanarelli described a bacillus, designated by him as "*bacillus icteroides*," that he had discovered in about 58 per cent. of yellow-fever cadavers examined by him at Monte Video. From its presence in only yellow-fever cadavers, its pathogenesis, and the peculiarity of the lesions produced in animals inoculated with it, he feels justified in regarding it as the specific exciting cause of yellow fever. He claims to have rendered animals immune from the disease by the use of his cultures of this bacillus, and he further states that the serum obtained from such immune animals has the property of protecting individuals into whom it may be injected from yellow fever. A comparison of the descriptions of these two organisms leaves little doubt that they are closely related, though not identical; that they can reasonably be embraced within the colon group of bacilli; and that the results of inoculations of animals with them do not, in the majority of cases, materially differ from those obtained occasionally through the injection of the colon bacillus or some one of its varieties.[1] As a result of these facts, the opinion expressed

[1] Reed and Carroll (*Medical News*, April 29, 1899) have subjected "*bacillus X*" and "*bacillus icteroides*" to exhaustive study, and as a result reach the following important conclusion: "We venture to express the opinion that *bacillus icteroides* (Sanarelli) is a variety of the hog-cholera bacillus, and that

by Sanarelli as to its standing in causal relation to yellow fever has not met with general acceptance on the part of bacteriologists.

It has been suggested, or rather predicted, that if the cause of this disease is ever discovered it will be found to be a hæmatozoon, zoologically allied to the malarial parasite of man, but on this point there is as yet no evidence whatever.

Geographical Distribution.—According to Hirsch, the geographical limits between which it is possible for yellow fever to occur are represented in the western hemisphere by the latitudes 34° 54′ south (Monte Video) and 44° 39′ north (Halifax); and in the eastern hemisphere by 8° 45′ south (Ascension) and 51° 37′ north (Swansea). Within these boundaries there are localities from which the disease is never absent; others in which it is more or less frequently present, and others in which it only occasionally occurs as a result of accidental importation.

The three principal districts in which yellow fever is really endemic are the West Indies, the Mexican part of the Gulf coast, and the Guinea coast at Sierra Leone. The latitude of these localities is regarded by Guitéras as comprising the "focal zone" of yellow fever, while the coast of tropical Atlantic, both in America and in Africa, he designates as the "perifocal" zone, or the regions of periodic epidemics.

Epidemics of this disease were at one time frequent in this country, especially during the last and the early part of the present century. In late years they have undergone a conspicuous decline in frequency. The last extensive epidemic of yellow fever in the United States occurred in Louisiana, Mississippi, and Alabama in 1878. Severe epidemics occurred in this city (Philadelphia) in 1693, 1762, 1793, and 1802. In the epidemic of 1793, the most serious outbreak of the disease that has ever occurred in a city of the Middle States, the mortality for the four months of its continuance was about 10 per cent. of the entire population of the city.

it should be considered only as a secondary invader in yellow fever. We find that *bacillus X* (Sternberg) presents marked differences from the foregoing micro organisms. . . ."

Race Susceptibility and Immunity.—Absolute immunity from yellow fever is not possessed by any peoples as a natural, racial characteristic.

Relatively speaking, those peoples, be they Europeans, Africans, or Creoles, who are permanent residents in the endemic zones of the disease, exhibit less susceptibility than do newly arrived strangers from the colder, more northern or southern latitudes.

According to Townsend (quoted from Hirsch) "the mortality of vomito[1] to the new-comer from the cooler latitudes may be said to be in an exact ratio to the distance from the Equator of his place of nativity and residence."

Barton presents the following instructive statistics upon the comparative mortality among strangers and natives in the epidemic at New Orleans in 1853. This illustrates very well the statement made by Townsend.

Of each 1000 deaths from yellow fever that occurred among various races exposed to it, there were of—

Native Creoles			3.58
Strangers from	West Indies, Mexico, and South America		6.14
"	"	Southern United States	13.22
"	"	Spain and Italy	22.06
"	"	Middle United States	30.69
"	"	New York and New England	32.83
"	"	Western United States	44.23
"	"	France	48.13
"	"	British America	50.24
"	"	Great Britain	52.19
"	"	Germany	132.01
"	"	Scandinavia	163.26
"	"	Austria and Switzerland	220.08
"	"	The Netherlands	328.94

It is sometimes said that the Creole and the African are naturally immune from yellow fever. This is not true. At birth neither of these peoples is insusceptible, and Guitéras states that "the foci of endemicity of yellow fever are essentially maintained by the Creole infant population."

Since a single, non-fatal attack of yellow fever affords

[1] A synonym for yellow fever.

more or less complete protection from subsequent attacks, it is plain that by prolonged residence in the zones of endemicity and constant exposure to infection a certain proportion of the population, including all races, acquires such resistance, by having passed safely through this fever. It is interesting to note that the so-called "acclimatization" to this disease that many natives possess is more or less completely lost after removal to cooler latitudes, and that such individuals on their return to the zone of endemic yellow fever often exhibit a degree of susceptibility equal to that of total strangers to the district.

Seasonal and Geographical Influences.—Yellow fever is most common in low lands along the coast, and along great rivers in hot climates. It rarely or never occurs at high altitudes. When it breaks out in cities, they are usually low-lying, badly-drained, and in an unsanitary condition generally. It usually appears first in the poor and overcrowded districts. It is a disease of summer, though it may persist for a time after the advent of cool weather. It is promptly checked by frost, though this does not permanently eradicate the poison, for the disease may reappear with the advent of warm weather again. It has been observed that on infected ships the disease will sometimes disappear as they sail to cooler, northern latitudes, and will reappear with return to the warmer climate.

Dissemination.—The tropical districts from which yellow fever is never absent—*i. e.*, the focal zone—manifestly offer certain climatic and telluric conditions that are directly favorable to the development and perpetuation of the yellow-fever virus. Whether this virus is located in the soil or in the water of these localities, or whether it is disseminated by the water, the air, or by insects, it is impossible to say, since nothing whatever is known as to its nature or habitat.

There is an abundance of evidence to show that yellow fever is often conveyed from place to place along lines of traffic, both by sea and land. Ships and their cargoes are regarded as frequent means of conveying the disease. The poison is known to have clung persistently to the hulls of

particular ships. Old wooden ships are looked upon with much greater suspicion than are the more modern ones built of iron, though the latter are by no means proof against the invasion of the poison. From time to time an outbreak of the disease in a locality is coincident with the arrival and unloading of a ship from an infected port, notwithstanding the fact that she may have had no cases of yellow fever among the crew or passengers during the voyage. The disease is undoubtedly conveyed by articles of merchandise, mail matters, clothing, and other objects that have been in localities where yellow fever is epidemic. Such fomites that have been in the immediate vicinity of these patients are considered especially dangerous.

Though opinion is opposed to its direct transmission from the sick to the well (contagion), still there are good grounds for the belief that patients and convalescents have been the agencies by which the disease has been carried from epidemic or endemic centers into other localities that offered conditions favorable to its development. It appears likely that the mode of dissemination is analogous to that of cholera and typhoid fever, and is in no wise similar to the direct transmission observed in small-pox, measles, and other highly contagious maladies.

Experience has shown that persons in attendance on the sick are not especially liable to contract the disease, and yellow-fever patients have often been brought into the wards of general hospitals among susceptible patients, without the disease having been disseminated.

Prophylaxis.—The most important measure against the introduction of yellow fever into a locality is good general sanitation, including clean and well-drained streets, proper disposal of garbage and excreta, prevention of overcrowding, an abundant supply of pure water for domestic purposes, and a competent system of quarantine.

With the occurrence of the disease all cases should be isolated. Their discharges, including those from the bladder, bowels, and vomited matters, also all the soiled body- and bed-clothing, should be carefully disinfected. The sick cham-

ber should be clean and well aired. In case of death the body should be wrapped in a sheet soaked in a reliable disinfectant, placed in a close coffin, and buried or cremated at once. If buried, it should be in a place from which there would be no danger of the pollution of neighboring water-supplies.

Under the headings "Disinfection of Apartments" and "Disinfection of Ships" will be found the steps necessary to render quarters occupied by those patients free from danger.

DENGUE.

Definition.—A specific, epidemic, febrile disease of tropical and subtropical countries, that is characterized by suddenness of onset, severe pains in the muscles and articulations, the appearance of an initial and terminal rash, and by a tendency to terminate favorably in from three to four days.

It is also variously known as "breakbone fever," "dandy fever," "three days' fever," etc. It is certainly infectious, though no micro-organism has as yet been proved to stand in causal relation to it.

Its outbreak is favored by high temperature and by geographical location more than by any other known factors. It is most apt to occur, even in the tropics, during the warmest months. In higher latitudes, that are still within its epidemic zone, the greatest number of outbreaks have occurred during summer and early autumn. It rarely develops at a temperature below 64° F. (Hirsch), and its progress is, as a rule, suddenly checked by the onset of cold weather and the occurrence of frost.

It is a disease of low-lying localities along the coast, especially of overcrowded, unsanitary towns and cities. It rarely extends into the country, and only very exceptionally has it been observed at high altitudes.

Neither physical conditions of the soil, nor such meteorological influences as atmospheric moisture, rain, and wind, have any apparent influence upon the course and occurrence of the disease so long as the temperature remains favorable.

Neither race, age, sex, nor social condition is regarded as a conspicuous factor in either predisposing to or protecting from dengue.

The march of the disease through a community is often so rapid that from 60 to 75 per cent. of all the inhabitants will be affected within a few days of its primary appearance.

By certain authors dengue is said to simulate yellow fever in some respects. By others it is regarded as predisposing to subsequent infection by yellow fever, cholera, typhoid, or malaria. By some a single attack is thought to afford protection, by others this is denied.

In marked contrast to the severity of the symptoms of this disease stands the rarity with which it proves fatal. It is apparently dangerous for only the very young and those of the aged who are already affected with grave organic lesions. Many epidemics pass away with no deaths at all, and even in the severest the number of deaths has "not yet reached as high as 0.5 per cent. of those affected" (Scheube). It is said to occur among animals (horses, cows, dogs, and cats).

Dengue has been recognized as a distinct disease since 1824, though descriptions of an identical affection occurring in Egypt, Spain, Java, and India were given in the latter part of the eighteenth century. During the present century it has appeared on a number of occasions in India, Africa, the West Indies, and southern United States. The first recognized epidemic in this country occurred in Savannah, Ga., in the fall of 1826. During the two following years it spread throughout the southern States, the West Indies, and the northern coast of South America. Between 1848 and 1850 and in 1854, widespread epidemics occurred along the Mississippi valley and in the southern Atlantic seaboard States. The last epidemic occurred in 1873 in Alabama, Mississippi, and Louisiana. The "bilious remitting fever" described by

Rush in 1780, as occurring in Philadelphia, is regarded by Hirsch as dengue fever. The zone of epidemicity of this disease is embraced between lat. 32° 47′ north (Charleston, S. C.) and 23° 23′ south (St. Paulo, Brazil) (Hirsch).

Dissemination.—It is questionable if dengue is contagious. At first sight, its rapid spread throughout a community may be attributed to a very high degree of contagiousness. On further inquiry, however, this seems to be erroneous. Like influenza, with which it is held by some to be closely allied, by others to be identical, it has been observed to spring up suddenly at various points in the same locality among persons who have had no communication with one another. Its rapid spread is therefore regarded as due more to the simultaneous infection of large numbers of individuals from a common focus or source, rather than from the transmission of the morbific material from person to person. Again like influenza, it is believed to be carried from place to place along lines of travel by land and sea. After the subsidence of an epidemic it occasionally happens that, in places of suitable temperature, dengue remains endemic for a time.

Prophylaxis.—As a rule, special preventive measures against dengue have not been practised, probably because of the comparative rarity with which the disease proves fatal; and indeed, until we possess some knowledge of its exciting cause and of its mode of dissemination, it will be difficult to institute a rational system of prophylaxis. The fact of its sudden and simultaneous occurrence among groups of individuals in the same locality, who have in no known way been exposed to contagion, and of the coincidence of epidemics in different places, illustrates the insidious nature of its dissemination and the, for the time being, ubiquity of the poison. Isolation of the sick, with disinfection of excreta, clothing, and apartments, might be practised, but it is doubtful if this would prove of any marked influence in checking the march of the epidemic.

TYPHUS FEVER.

Definition.—A specific, contagious fever characterized by a maculated rash, extreme depression of the vital powers, nervous derangements, and a tendency for non-fatal cases to terminate by crisis in about two weeks.

It is also variously known as "spotted fever," "jail fever," "camp fever," "ship fever," and "hospital fever." Its specific exciting cause is not known, though doubtless such a factor exists. It is universally admitted that the most important influences that predispose to its epidemic occurrence are widespread destitution and misery, with their usual concomitants—viz., overcrowding, filth, poor and insufficient food, intemperance, and inadequate clothing and shelter.

In former years epidemics of typhus fever occurred with comparative frequency, both in Europe and in this country; but latterly—*i. e.*, during the past twenty-five years—by reason of the sanitary improvement that conditions of life have everywhere undergone, its visitations have become fewer until it has practically disappeared, as a dreaded pest, from among civilized peoples.

Distribution.—The occurrence of typhus fever is not markedly influenced by geographical location, though it is usually regarded as more likely to occur in temperate and cold than in the warmer climates, possibly because of the conditions favorable to open-air life that the latter afford.

Its epidemic outbreak is, as a rule, referable to the predisposing influence of the social condition of the people among whom it occurs. The history of the disease, during the time when it was more frequent than it is to-day, points directly, as stated above, to widespread destitution and misery, with all that they entail, as the important factors in determining the development of an epidemic. Up to about the middle of the present century it had occurred epidemically in many parts of both the eastern and western hemispheres.

Australia, New Zealand, Japan, a large part of Africa, and parts of southern Europe have been comparatively free from the disease. According to Hirsch, endemic centers have be-

come established in only a few countries, notably in Ireland, Russia, and Italy, and even here they are of but limited extent. Telluric and seasonal influences do not appear to be of much, if any, importance in deciding an epidemic outbreak.

In 1883 a small epidemic of typhus fever occurred in the Philadelphia Hospital, and in 1881 to 1882 over 700 cases were admitted to the Riverside Hospital in New York. Other than these, there have been no outbreaks of any moment in this country since those that occurred between 1867 and 1870.

Dissemination.—Typhus fever is highly contagious, in the strict sense of the word, and there is probably no disease that has been more frequently contracted from patients by physicians and nurses. The specific virus, of whatever nature it may be, appears to be distinctly transmissible from the sick to the well through the surrounding air. Whether it is usually received by way of the air-passages, or through the alimentary tract, or whether infection may occur through wounds, cannot be stated, as nothing is known of the causative agent.

The poison may be harbored by and carried from place to place in fomites. As stated, the activities of the specific virus are favored by unsanitary conditions, and if cases of the disease be introduced into overcrowded, filthy, and generally unhygienic localities, there is every likelihood of an epidemic outbreak of the fever. By some writers it is believed to be carried from the sick to the well by insects.

The disease is less common among the very young and the aged than during the periods of youth and early maturity. Its occurrence is not influenced by sex.

Prophylaxis.—It is manifest that the most important prophylactic measures against this fever are those that aim to prevent its introduction from without, and those that are designed to eliminate all local conditions favorable to its development.

The former comprise the functions of such properly constituted systems of quarantine as should exist at all populous seaports; the latter represent the duties of legally author-

ized boards of health. The scope of the work should embrace the strict sanitary supervision of overcrowded localities, such as exist in all the poorer districts of great centers of population, and should be especially directed to the general hygiene of places designed for both permanent and temporary residence by people of such localities—as, for instance, tenement-houses, work-shops and work-houses, jails, reformatories, almshouses, and hospitals. Especial attention should be given to the cleanliness, the ventilation, the condition of crowding, the water-supply, and the sewage of these places. Careful watch should be kept for the occurrence of suspicious cases, and these should be isolated in properly equipped hospitals as soon as detected.

The influence of fresh air upon the virulence and vitality of the virus of this disease is apparently of very great importance, and many of those who have observed the epidemic outbreak of typhus fever in hospitals have been struck by the rapidity of its disappearance when the patients were removed from the wards and placed in tents in the open. Isolation in freely ventilated apartments, and careful disinfection of bed- and body-clothing and excreta are always called for. Isolation should be rigidly enforced, because of the highly contagious nature of the disease; and for the same reason the physician and attendants should spend no more time than is necessary in the immediate proximity of the patient.

The sick chamber, as well as all furniture and other articles contained in it, should be disinfected and thoroughly aired after the removal of the patient.

RELAPSING FEVER.

Definition.—"Relapsing," "Famine," or "Seven Days' Fever," is an infectious disease that results from the presence in the blood of a specific micro-organism discovered by Obermeier and now generally known as *spirochæta Obermeiri.*

The disease is characterized by acute febrile paroxysms that last from six to seven days. These are followed by an intermission of the same length of time, when the acute symptoms reappear. It is from the occurrence of these relapses that the fever takes its name.

The organism causing the disease is a spiral-shaped thread that may be seen moving about among the corpuscles in blood drawn during the paroxysms (Fig. 25). They disap-

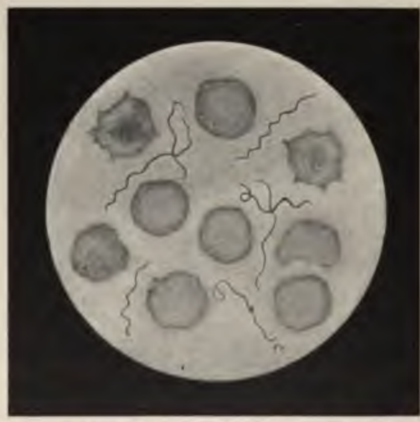


FIG. 25.—Showing spirochæta of Obermeier in blood of relapsing fever patient.

pear from the blood until the crisis of the fever, and are but very rarely to be detected during the period of intermission. In dried blood preparations the spirochæta may be stained by the usual methods. It is decolorized by Gram's method. It varies in length, being sometimes hardly longer than the diameter of a red corpuscle, while at other times it is many times this length. Nothing is known of its life history. It has never been reared artificially.

By inoculation with blood from these patients the disease

has been induced in men and in monkeys, though in the latter only the primary acute fever occurs and there is no tendency to recur. The organism has been kept alive outside the human body for about a week, by keeping on ice leeches that have been allowed to fill themselves with blood from these patients.

The conditions that favor the development of typhus fever —viz., squalor, filth, destitution, etc.—likewise favor the development of relapsing fever, and the two diseases have been observed together in the same locality.

Distribution.—Quoting Hirsch, the first trustworthy account that we have of this disease on European soil is given by Rutty in 1770 in his chronological history of the prevailing diseases of Dublin. In this publication he directs attention to an epidemic of this fever that occurred in Dublin in 1739. The fever has been more prevalent in Ireland, Scotland, Russia, parts of Germany, northern Africa, and India than elsewhere. It had not appeared in Australia up to 1875. It was first observed in this country, in Philadelphia, in 1844. It has not appeared in the United States in epidemic form since 1869, when it prevailed extensively in New York and Philadelphia.

It is not apparently influenced by age, sex, season, or telluric conditions, though it is said to have occurred more frequently in the temperate and cold than in warm climates.

Dissemination.—It is said to be contagious, though less so than is typhus fever. Latterly, attention has been directed to the possibility of its being spread from the sick to the well by the bites of insects—a reasonable opinion in view of the fact that the disease may be induced through the inoculation of healthy persons with blood from those suffering from the fever.

The causative agent is said to be transmissible by fomites.

Prophylaxis.—Since the social conditions that favor the development of typhus likewise favor the development of relapsing fever, the prophylactic measures recommended for the former serve equally well for the latter disease.

RABIES.

(*Lyssa; Hydrophobia.*)

Definition, Cause, etc.—A specific infectious disease communicable from animals to animals and to man, commonly by a bite.

When occurring in animals it is known as rabies or lyssa; when in man, as hydrophobia, not because of the actual fear of water, as the name signifies, but rather because of the dread felt by the patient of the severe spasm of the muscles of deglutition that is experienced in efforts to swallow water.

In the rabid animal the virus of the disease is contained in the saliva, and it is through wounds made with the teeth, or wounds to which saliva from such animals gains access, that rabies is transmitted.

Numerous efforts have been made to detect the etiological factor of rabies, but as yet no trustworthy results have been reached. Nevertheless, it has been demonstrated that a poison is present in the tissues of animals suffering from or dead of the disease—especially in the tissues of the central nervous system—that is capable of setting up the disease in other animals into which may be inoculated. Though the actual cause of rabies has not been detected, still, the behavior of the tissues that are particularly rich in the poison corresponds in so many ways with that of tissues containing a living virus as to leave little doubt that the disease originates with the invasion of a specific micro-organism, or the introduction of a poison resulting from the development of such an organism. Thus, for instance, the poisonous properties of the medulla are destroyed in a few minutes by exposure to 50° C., by subjection to various disinfectants, by prolonged action of sunlight, and by drying, all of which reactions, as we know, are common to tissues containing living micro-organisms.

The animals most frequently affected are dogs, wolves, cats, jackals, and skunks, though the disease is transmissible to horses, bovines, swine, sheep, deer, etc. When once well established, the disease is almost invariably fatal. The dog

is the chief sufferer from rabies, and is the principal, if not the sole, means of its propagation (see Table XI.).

TABLE XI.—*Compiled by Fleming, giving the number of cases of rabies, and the species of animal in which they occurred, in England during the four years ending with 1890*:[1]

Kind of Animal.	1887.	1888.	1889.	1890.
Dogs	217	160	312	129
Cattle	11	2	9	2
Sheep	5	7	11	
Swine	3	. .	4	1
Horses	4	5	4	2
Deer	257	2		
Total	497	176	340	134

Rabies is communicable to man, as stated, by the bite of a rabid animal. Bites received upon exposed surfaces, as upon the head, face, and hands, are usually more serious and more certain to be followed by hydrophobia than are those upon the clothed portions of the body, owing, doubtless, in the latter case, to the virus being wiped from the teeth in their passage through the clothing.

The period of incubation of hydrophobia ordinarily varies from about six weeks to two months, according to circumstances. In some cases it is shorter—as short as two weeks; in others it may be delayed for a year or more after the reception of the bite. The bite of the rabid wolf and cat is more certain to be followed by hydrophobia than is that of the dog.

The fatality among individuals bitten by dogs proven to have rabies is in general 15 per cent., while for those cases in which the bites were received upon exposed surfaces the figure rises to from 60 to 80 per cent. No country is exempt from rabies except, perhaps, Australia and New Zealand (Fleming), and it is excluded from those places only through a careful quarantine of all dogs coming into the country.

It is more prevalent in some countries than in others,

[1] See Fleming: "The Propagation and Prevention of Rabies," *Trans. Seventh Internat. Cong. Hygiene and Demography*, 1891, vol. iii., p. 16.

owing in part to the stringency of dog laws in localities where it is rare, and the laxity or absence of such laws from those places in which it is more common.

Rabies is especially prevalent in Russia, Belgium, Austria, France, and England. It is rare in Germany and Switzerland, because of the regulations governing dogs, and for some reason or another it is not very common in this country. The cases seen in Germany have, in the majority of instances, been in the provinces along the Russian border.

Since the dog is the most frequent sufferer from this disease, and the commonest source from which hydrophobia is contracted by human beings, it is manifestly important that it should be recognized in its earliest stages.

Symptoms.—A dog bitten by another that is mad may show signs of rabies within a few days—ten to fifteen—or, as in latent rabies, evidence of the disease may not appear for months. The symptoms of rabies in the dog warrant the division into "furious" or "excitable," and "paralytic" or "dumb" rabies, though sharp lines of distinction cannot always be drawn. After the earliest signs of madness, that usually manifest themselves by quietness, sullenness, disinclination for company, alterations in the general psychical nature, perverted appetite, and conspicuous alteration in voice, the animal may become markedly excited or furious, or paralysis may set in. If the former, he will often trot about over large tracts of country, with head and tail depressed, tongue hanging from the jaws, and snapping[1] at all objects that come in his way. It is in this stage that the dog is most dangerous to other animals.

From loss of food and sleep and excessive nervous excitement the animal rapidly becomes emaciated and haggard. Death usually results in a convulsion, of which the dog may have many toward the later stages of the disease.

If the disease assumes the paralytic form, there is usually no period of excitement; but after the preliminary symptoms evidences of paralysis, beginning with the muscles about the

[1] Responsible authors do not regard the "snapping" as deliberate, but rather as reflex.

face and jaws—especially of the lower jaw—are observed. Paralysis is progressive until the death of the animal.

While the clinical aspects of these manifestations of rabies are totally dissimilar, they are still regarded as etiologically identical, and do not therefore constitute distinct diseases.

The mode of diagnosing rabies that is now regarded as the most trustworthy is only possible after the death of the animal, but even then it is manifestly often of the utmost importance to know definitely the nature of the malady, in the event of the dog's having bitten persons or other animals.

This method of diagnosis consists in the introduction of a small portion of the medulla from the mad dog beneath the dura mater of a rabbit. After a period of incubation of from twelve to eighteen days, the rabbit evinces beginning paralysis; this is progressive until death. The form of rabies thus transmitted *to the rabbit* is always paralytic, though the same material may be capable of inducing either the furious or the paralytic variety in dogs inoculated in a similar manner. By the repeated transference of bits of medulla from one rabbit to another, by this mode of inoculation, the disease may be propagated at will.

Prophylaxis.—The statistics on this disease from different countries, without exception, demonstrate that adequate laws concerning the keeping of dogs, when properly enforced, constitute the most potent factor for its suppression. Such regulations should provide for:

The immediate destruction of all dogs known or believed to be suffering from rabies, and the secure isolation and careful observation of all animals that may have been bitten by such dogs.

The seizure and destruction of all vagrant dogs.

The imposition of a tax upon the owners of dogs, and the punishment by fine of all persons detected in evading this tax.

During the prevalence of rabies, and for a time afterward equivalent to the longest period of latency, all dogs should be muzzled. The non-observance of this provision on the part of the owners to be punishable with fine.

There are numerous instances in which the adoption of such regulations has caused, within a short time, the almost total disappearance of rabies from neighborhoods in which it prevailed. Thus, for instance, there were 107 mad dogs killed in Berlin during an outbreak of the disease in 1852; on July 2, 1853, a decree was issued to the effect that all dogs should be muzzled, and all not so secured should be killed; in the year following this decree there was only *one dog* destroyed as rabid. It was subsequently found necessary to extend this decree to the whole of Prussia, as the muzzling and destruction of dogs in Berlin alone were not sufficient to eradicate the disease totally.

Within eighteen months after the adoption of the muzzling law in Vienna rabies was totally suppressed. In the Grand Duchy of Baden the numbers of cases of rabies that occurred annually, from 1871 to 1875 inclusive, were 18, 37, 50, and 43. In 1876 the muzzle was applied, with the following results: in 1876 there were 28 cases; in 1877, 3; in 1878, 4; in 1879, 2; in 1880, 2; in 1881, 2; in 1882, 3; in 1883, 2; in 1884, 2.

In Prussia preventive measures have reduced the deaths from hydrophobia in human beings from a yearly average of 166 cases for the ten years ending with 1879, to a yearly average of 4.5 cases for the decade ending with 1886.

The foregoing statistics, taken from Fleming's paper, referred to above, while representing only a portion of the material presented by him in support of his argument for the suppression of rabies, are still sufficient for our purpose to demonstrate what may be accomplished by intelligent and conscientious attention to this important subject.

Preventive Inoculation.—The principles involved in the practice of preventive inoculations against rabies and hydrophobia are essentially those on which all other modes of preventive inoculation are based; that is to say, they contemplate the establishment in the animal under treatment of a tolerance to the virus of the particular disease from which it is being protected. This is usually accomplished by the repeated inoculation of doses of the virus that are so small,

or of virus so attenuated in potency, as not to imperil the life of the animal, beginning usually with very minute doses and gradually increasing them until the animal can finally withstand, without injury, what would otherwise be a fatal dose of the fully virulent virus. When this point is reached, the animal is protected. In the majority of instances the protection thus afforded is believed to be due to specific systemic reactions, following upon each injection, by which the tissues acquire a tolerance to the poisonous properties of the materials used. In this particular instance, as indeed in all others, the essential starting-point is a virus of fixed and known toxicity.

The virus obtained from the medulla of a dog dead from the ordinary rabies of the street ("*rage des rues*"), when inoculated into a rabbit, has a period of incubation of from fifteen to twenty days, rarely or never less than eleven days. By passing such virus from rabbit to rabbit through a long series, the incubation period becomes gradually shortened until it finally reaches a fixed point of from six to seven days ("*virus fixe*"). As a rule, this is the strongest and most stable virus that can be obtained.

If the medulla from a rabbit that has died after inoculation with this fixed virus be preserved in a dry atmosphere, its toxicity gradually becomes lessened as the drying proceeds, and totally disappears in about two weeks if the drying has been at a temperature of from 23° to 25° C. With the medulla so treated the period of incubation, as determined by the inoculation of rabbits, becomes longer as the virus becomes attenuated in the degree of its potency. In Pasteur's protective inoculation, the treatment is begun with the subcutaneous injection of emulsions of spinal cords or medullæ that have been thus dried until almost robbed of their toxic properties; this is followed by similar injections of emulsions from more and more toxic tissues, until finally the animal is prepared for an injection with the strongest—*i. e.*, "fixed virus;" when this stage is reached, protection is assumed to be completed.

For the successful employment of this method it is essen-

tial that it be begun at the earliest possible moment after the reception of the virus—*i. e.*, after the bite of the rabid animal. The greater the delay the less likely is the treatment to be effectual.

The influence of this mode of treatment upon the mortality from hydrophobia among human beings bitten by rabid animals is so striking as to efface all question as to its efficacy. As stated above, a fair average mortality for all cases of bites from mad animals is 15 per cent., while the mortality among those bitten upon the head, face, neck, and hands, ranges from 60 to 80 per cent. The following table, compiled by Pottevin, illustrates the striking reductions in these death-rates that have been accomplished through this mode of treatment in the Institute Pasteur at Paris.

Table showing the results of the Pasteurian preventive inoculation against hydrophobia in human beings, for the twelve years ending with 1897:[1]

Years.	Persons treated.	Deaths.	Mortality (per cent.).
1886	2671	25	0.94
1887	1770	14	0.79
1888	1622	9	0.55
1889	1830	7	0.38
1890	1540	5	0.32
1891	1559	4	0.25
1892	1790	4	0.22
1893	1648	6	0.36
1894	1387	7	0.50
1895	1520	5	0.33
1896	1308	4	0.30
1897	1521	6	0.39

[1] See *Les Vaccinations Antirabiques à l'Institut Pasteur en 1897*, par Henri Pottevin; *Annales de l'Institut Pasteur*, 1898, tome xii., p. 301.

DISEASES DUE TO HIGHLY-DEVELOPED ANIMAL PARASITES.

It is manifestly inadvisable to attempt in a book of this character the detailed treatment of so large a subject. The following must, therefore, be regarded as a mere sketch of the more frequent and important conditions observed in man as a result of the invasion of the body by the commoner animal parasites.

As has been already intimated in the first section, the disturbance of physiological function and the morbid conditions that arise from the presence of entozoa in the body are in the main due to their character, mode of development, their local irritation, to the demands that they make upon the blood and tissues for nutrition, and to their obstructive action when located in important viscera and organs of special sense. With the exception of the blood-sucking *ankylostoma duodenale*, those that occupy the alimentary tract cause only disturbances of the digestive processes and reflex nervous phenomena, and are not accompanied by definite or serious structural lesions. Those located within the tissues cause irritation which may in time be followed by more or less of inflammatory reaction. Certain of these, by developing to an unusual size (echinococcus cyst), may seriously obstruct the functional activity of the organ in which they are located; while those occupying a position in such important vital parts as the central nervous system, the organs of special sense, and the circulatory apparatus, may result in the gravest disturbances, and even in death.

Diseases of this class, and especially those in which the parasite resides within the alimentary tract or internal viscera, are most frequently contracted through the swallowing of either the mature parasite or its eggs, or its larval forms.

As a rule, the commonest worms of man enter the body as larvæ with the flesh of animals in which the first stages of development of the worm have taken place; or in some instances they may be derived directly from domestic animals whose flesh is not used as food, but with which the individual

may have been in intimate association; or in other cases they may be traced to the eggs of parasitic worms that are contained in polluted drinking water.

The Nematoda.—These worms are so called because of their filiform or thread-like shape. The commonest species are:

Ascaris Lumbricoides (*Round Worm*).—It is in general similar in appearance to the ordinary earth-worm. The females measure about 30 cm. (12 inches), and the males about 15 cm. (6 inches) in length. It locates in the small intestine of man, and, as development proceeds, a large number of eggs are passed. The eggs are brownish in color, as seen in the stools, and are of a barrel shape. The eggs are carried by water, and it is through the drinking of water polluted with them that the individual often becomes infected. The worm is also seen in swine, and for this reason water polluted with hog excrement should be viewed with suspicion.

Oxyuris Vermicularis (*Thread Worm*).—This worm invades the cecum and upper colon. The female, which is about 12 mm. in length, deposits eggs in very large numbers. Within these eggs spermatozoa-like embryos may often be detected. When swallowed, the envelope of the embryo is digested by the gastric juice and the larvæ liberated. They pass through the early developmental stage in the upper intestine and reach maturity in from twenty-five to thirty days. Raw vegetables or insufficiently cooked vegetables are said to be the most frequent source of infection. The larvæ are destroyed by long immersion in water.

Trichocephalus dispar (*whip-worm*) is the commonest intestinal parasite of man in tropical latitudes. It retains its vitality in water and in moist soil. The embryos in the egg are very tenacious of life. When the egg is swallowed, the larva is liberated in the alimentary canal, attaches itself to the wall of the intestine by its lash-like extremity, and proceeds to develop slowly, reaching maturity after about ten or twelve months.

Ankylostoma duodenale is a minute worm, which by its presence in the upper portion of the small intestine causes

the disease called *ankylostomiasis,* or *Egyptian chlorosis.* The parasite becomes attached, often in enormous numbers, to the villi of the duodenal mucous membrane. Through the continuous draught that it makes upon the circulating blood there results the condition of anemia by which the disease is characterized clinically, and from which it takes its popular name. The parasite is apparently widely distributed, as the disease has been observed in Egypt, India, Italy, Africa, Peru, and Australia. An analogous disease, known as " miners' cachexia," " miners' chlorosis," " tunnel disease," has been observed among Italian workmen in the St. Gothard tunnel. It has also been known among Italian brickmakers and in those who have worked upon the irrigation fields. The disease is said to have been known for some years among the coal miners of Belgium and the brickmakers of Cologne as " brick-makers' anemia." The development of this parasite seems to be favored by wet, marshy soil. In appearance the parasite is whitish or brownish in color, and in shape it is cylindrical, with more or less pointed ends. It measures from 6 to 18 mm. long and about 1 mm. in thickness. The male has a bell-like expansion at its posterior extremity. It attaches itself, as said, to the mucous membrane of the duodenum and upper jejunum, by means of a set of tooth-like hooks with which the mouth is provided. The eggs of this parasite are ejected with the feces, and probably undergo further development when favorable conditions, such as soil-moisture, high temperature, and free access to air, exist.

Infection probably occurs through the drinking of water from marshy soils on which the eggs are deposited with the feces of individuals in whom the entozoon is present, or in some one or another of the manifold ways that are open to men working in and upon such infected areas. It is almost exclusively seen in persons whose occupations bring them in contact with earth, as the various synonyms of the disease imply.

It is obvious that the precautions to be taken to prevent infection and dissemination are to drink only boiled or fil-

tered water, pay particular attention to personal cleanliness, especially of the hands, and to disinfect carefully the stools from all individuals in whom the parasite is present.

Rhabdonema Intestinale. — Frequently associated with ankylostoma duodenale is the nematode *rhabdonema intestinale*, the parasite that is concerned in the causation of the so-called "diarrhea of Cochin China."

The lodgement of the female worm, which is about 2 mm. long and hardly thicker than a hair, in the intestinal tract is quickly followed by a brood of embryos that are hatched from eggs in the canal. The embryos bear some resemblance to those of ankylostoma, but differ from them in being hatched while in the human host.

The presence of this parasite in large numbers is accountable for a persistent diarrhea so often observed in Cochin China, Brazil, West Indies, Egypt, Ceylon, Italy, and other tropical countries.

In marked cases of the disease the daily extrusion of the worms, which accumulate in all parts of the intestinal canal, is said to reach enormous numbers, having been estimated at 100,000.

The disease is contracted in the same way as is ankylostomiasis, and the precautions that are recommended to be taken against the one serve equally well against invasion by the other parasite.

Dracunculus medinensis (*filaria medinensis*, or *Guinea-worm*) productive of the condition known as *dracontiasis.*

This is a nematode which in the mature form may measure from 60 to 80 centimeters (24–30 inches) in length and from 0.8 to 2 mm. (0.03-0.08 inch) in thickness. It enters the body, most probably by the mouth, as an embryo or larva contained in the body of the fresh-water flea, cyclops. On reaching the stomach the enveloping structures are digested and the embryo liberated. Rapid development now begins, and on reaching sexual maturity the adult worms proceed to reproduce. After impregnation the female wanders from the alimentary tract toward the subcutaneous tissues, where she remains for a

time until she finally breaks through the skin, causing a point of ulceration or abscess-formation. The male worm disappears after having performed his function of fecundation. On being discharged from the body, either by the breaking of an abscess or through the open surface of an ulcer that results from her presence in the subcutaneous tissues, the female worm is literally packed with living embryos. These find their way into water and, as stated, find in the cyclops an intermediate host favorable to their perpetuation.

The disease dracontiasis, or, as it is commonly called, Guinea-worm disease, and the parasite causing it, have been known for a very long time. Historians tell us that there are reliable records of it dating as far back as 150 B. C. Indeed, the reference made in the fourth book of Moses (Numbers, Chap. xxi, verse 6) to "the fiery serpents" with which the children of Israel were affected during their forty years' wandering in the wilderness has been interpreted as relating to this parasite.

The Guinea-worm is encountered in many parts of the Orient; on the west coast of Africa; in southern America, particularly Guiana, Brazil, and certain of the islands of the Spanish-American group. Occasionally dracontiasis is seen in this country, but it is usually imported, though a case is reported by van Harlingen in a man who had never lived outside of Philadelphia.

It is interesting to note that in the majority of cases of this disease the parasite is detected, as a rule, in a locality as far removed as possible from the point of entrance into the body. Thus, for example, of 712 reported cases of the disease that have been compiled by Hirsch, the parasite broke through the skin of the foot or lower part of the leg in 641 cases.

From what has been said it is obvious that the measures to be taken against contracting and disseminating the disease are to drink only boiled water when in neighborhoods where the parasite is indigenous, and to burn the worm and dressings from the ulcer or abscess as soon as removed.

Filaria Sanguinis Hominis (*Filariasis*).—Under this head

reference is made to a nematode encountered in the tropics—especially in Brazil, Central America, Egypt, India, and China—that invades the human body and is associated with chyluria, hematochyluria, and elephantiasis.

The life history of this parasite, for much of our knowledge of which we are indebted to the studies of Patrick Manson, of Brisbane, is, like the *filaria medinensis* and other filariæ, not completed in a single host.

The embryonic filariæ probably gain access to the body through the drinking of stagnant or polluted water in which they have been deposited by the mosquito, now regarded as the intermediate host.

Upon entry into the alimentary canal the young filariæ bore through the mucous membrane and take up their abode in the deeper lymphatics. When mature, the female worm, which is, according to Manson, about 3 inches long and about $\frac{1}{100}$ inch in thickness, is seen to be packed with embryos in all stages of development. These wander from the parent into the circulating blood and appear as tiny, actively moving, almost homogeneous worms that are readily detected by their lashing movement when a drop of blood containing

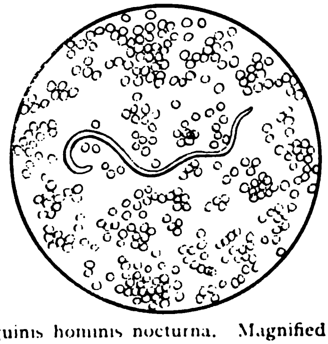


FIG. 26.—Filaria sanguinis hominis nocturna. Magnified about 200 diameters, showing relative size to the corpuscles of the blood

them is examined under the microscope (see Fig. 26). They are about $\frac{1}{3500}$ inch in diameter and from $\frac{1}{70}$ to $\frac{1}{80}$ inch in length.[1] At this point their development in man ceases, and

[1] See illustrated paper by Henry: *Trans. Assoc. Am. Phys.*, 1896, vol. xi., page 96.

can only progress further by the intervention of another animal that serves as an intermediate host. This, Manson believes, is the mosquito; which in sucking the blood from an infected person takes up the embryo filariæ, to deposit them subsequently in water, from which the cycle here outlined may be repeated. One of the most interesting features of this nematode is the periodicity of its excursions from the parent, or from the deeper lymphatics into the more superficial blood-channels, and owing to variations in this respect three different filariæ sanguinis hominis are recognized—viz., *f. s. h. nocturna*—*i. e.*, those that are to be found in the superficial blood-vessels *only* during the sleeping hours at night; *f. s. h. diurna*—*i. e.*, those found in the circulating blood only during the day; and *f. s. h. perstans*—*i. e.*, those that persist in the circulating blood throughout the twenty-four hours.

The interesting experiment of Mackenzie demonstrated that with at least one of these varieties—namely, *f. s. h. nocturna*—its habits vary with the habits of the individual in whom it is present. That is to say, they can be made to appear during the day and disappear during the night, by having the patient sleep during the day and remain awake during the night hours, just the reverse of their habits under normal conditions of waking and sleeping.

This parasite, as stated, is indigenous to several localities in the tropics. A sufficient number of cases have been reported in the United States, however, to justify the opinion that it must be regarded as a parasite that occasionally makes its appearance in the southern and middle States of this country, even in individuals who have not resided out of these localities.

The clinical phenomena observed in individuals infected with this parasite are chyluria, hematochyluria, and elephantiasis, especially of the scrotum. From time to time persons are encountered who are serving as hosts for this parasite, who are apparently in health and who evince no external evidence whatever of its presence, beyond the passage of chylous urine.

The chylous and hematochylous urine and the lymph-

scrotum are apparently the result of obstruction of lymphatic vessels either by the adult worm or by numbers of the embryos.

Trichina Spiralis (*Trichinosis*).—Within the muscles of animals infected with this parasite are to be seen tiny, opaque oval crystals measuring from 0.3–0.4 mm. (0.01–0.015 inch) in length and 0.12–0.15 mm. (0.005–0.006 inch) in breadth,

FIG. 27.—Trichina spiralis in muscle (under low magnifying power).

in which are spirally coiled, very small worms that can only be detected with the microscope (Figs. 27 and 28).

These bodies represent the embryonic stage of *trichina spiralis*. When swallowed the enveloping cyst is digested

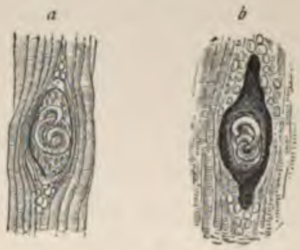


FIG. 28.—Trichina spiralis in muscle: *a*, in the early stages; *b*, capsule calcified (after Leuckart).

and the embryo liberated. It at once begins to develop and reaches sexual maturity in the intestinal canal after from five to six days. It is then white, of about the thickness of a hair and approximately 3 mm. (0.12 inch) in length. The male worm, which is the shorter of the two, measures from 1.5 to 2 mm. (0.06–0.08 inch) in length.

With sexual maturity the female worm begins to procreate

her species, giving off from 1000 to 1500 embryos as a brood, which at once begin to pass through the intestinal walls into the general musculature by way of the lymphatic channels. They penetrate the primitive muscular fibers, light up a limited inflammatory reaction, and become encysted. The cyst-wall or capsule gradually thickens and finally, in from six weeks to two months, becomes calcified (see Fig. 28, *B*). In this condition they appear as opaque, whitish, lens-shaped bodies lying among the muscle-fibers.

In the encapsulated condition the embryo may lie dormant in the muscles for a long time, "as long as twenty-five years after their entrance into the system."

It is of importance to remember that of the domestic animals whose flesh is used for food, the hog is the one by far the most frequently affected with this parasite, though it has occasionally been observed in the calf and sheep (see Fig. 29).

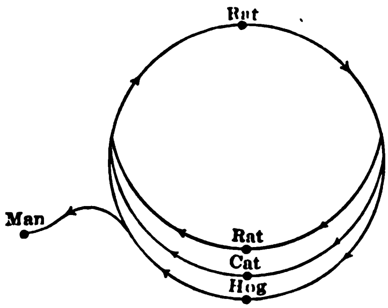


FIG. 29.—Life cycle and intermediate hosts of trichina spiralis (after Bollinger).

While the presence of trichinæ in the muscles of hogs causes apparently little inconvenience to the animal, their dissemination through the body of man in the disease trichinosis is followed by marked constitutional disturbances and not infrequently by death.

During the period in which the worm is confined to the intestinal canal the symptoms observed in man may be practically null in some cases. In others loss of appetite, diarrhea, and vomiting may occur. With the emigration of the embryos from the intestine to the muscles there appear fever,

depression, severe pain, and edema in and about groups of affected muscles. Involvement of the diaphragm, intercostal muscles, and those of the larynx causes distressing dyspnea that may prove fatal.

This parasite is observed in the flesh of hogs, cats, rats; less frequently in calves, sheep, dogs, mice, foxes, porcupines, and hedgehogs. Guinea-pigs and rabbits may be infected by feeding them with trichinous flesh.

They are readily detected, when present, in thin bits of muscle, by the use of a magnifying power of from 40 to 60 diameters. The muscles and tissues that contain them in greatest numbers are the tongue, laryngeal muscles, muscles of the jaw and loin, intercostals, and the lungs. It is especially at the tendinous insertion of these muscles that they congregate in greatest numbers. The search for them is greatly facilitated by cutting very thin strips from the suspected muscles, placing them between two heavy glass slides, which are to be pressed together firmly and examined with a power of 40 to 60 diameters. Calcified trichinæ may be rendered transparent by treatment with dilute acetic or hydrochloric acid.

Trichinæ are destroyed by heat (above 65° C.) in a few minutes, by drying in a short time, and by pickling in about two months. They are not killed by the ordinary process of smoking meat, and not certainly by as low a temperature as 20° to 25° C.

Infection occurs, therefore, commonly through the ingestion of raw meat or meat that has not been subjected to a sufficiently high temperature for a time necessary to kill the parasite.

The ratio between trichinous and healthy hogs slaughtered at the Berlin abattoir, between the years 1885 and 1895, was seen to vary annually from 0.22 per 1000 to 0.88 per 1000. During the past few years there has been a gradual diminution in the number of cases. Up to 1884 the statistics compiled by Salmon for trichinæ among hogs showed the disease to be present in a little over 2 per cent. of American swine, though official observations made since that date show

the disease to be growing less common. Of 1000 hogs examined by Osler and Clements in Montreal, in 1883, the disease was present in 0.4 per cent.

Cestodes (*Tæniæ*).—Another group of parasites, the cestodes or tape-worms, announce their presence in the body by mild constitutional symptoms, such as nervous irritability, indigestion, etc., but more especially by the appearance in the stools of the affected individual of segments of the adult worm.

There are several varieties of cestodes, the most important of which are *tænia solium*, or pork tape-worm; *tænia saginata*, or bovine tape-worm; and *bothriocephalus latus*, a tape-worm, rare in this country, that has been observed in particular species of fresh-water fish, especially the pike. As a rule, tape-worms are not dangerous to their host; they are readily eliminated by treatment, and easily guarded against by simple prophylaxis.

The tape-worms may be regarded as colonies of zooids, the individuals of which are strung together in single file, which gives to them the appearance of a bit of tape. The head is simply one of the group of zooids that is provided with either suckers or hooklets, which enable it to make fast to some portion of the intestine, and thus support from this fixed point the entire organism. The zooids or proglottides —*i. e.*, the segments of a tape-worm—are so constructed that they may each be regarded as a sexually complete organism.

A fully developed tape-worm ordinarily consists of about 1000 proglottides, which are computed to give birth annually to approximately 120,000,000 eggs, only a very small proportion of which, fortunately, come to maturity.

Man becomes infected with these parasites by swallowing the ova from ripe segments of the worm. The results of swallowing the ova may be either the development of a sexually mature worm in the intestine, or the permeation of the muscles and viscera by the larva—*cysticerci*—that remain as such because of their incapacity to advance to sexual maturity in these localities. In the former case there is little danger, while in the latter the conditions produced may or

may not be serious, depending upon whether the cysticerci are deposited in important vital organs or not.

The commonest tape-worms that are found in the intestine are the pork tape-worm, the beef tape-worm, and the *bothriocephalus latus*, especially the former two; while the visceral manifestations of these parasites are usually due to the permeation of the tissues and organs by the larva of *tænia solium*—*i. e.*, by the *cysticercus cellulosæ* and the larva of *tænia echinococcus*.

Tænia Solium (*Pork Tape-worm*).—This parasite is less common in America than in Europe. It occurs in man as a result of eating raw or imperfectly cooked pork, or food contaminated with the ova from the mature worm.

The mature *tænia solium* measures about three or four meters in length, and consists of about 800 proglottides, only

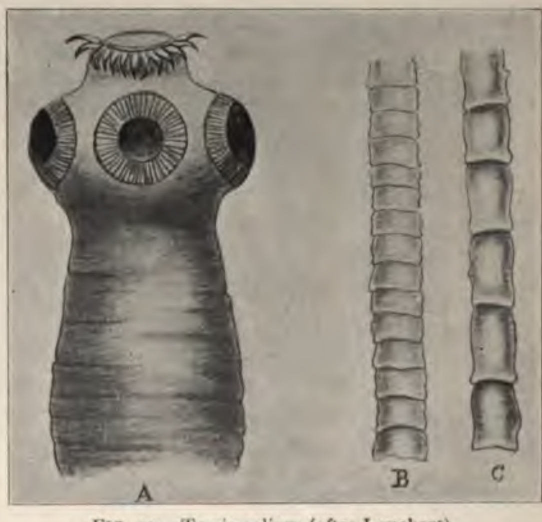


FIG. 30.—Tænia solium (after Leuckart).

about the terminal eighth of which are sexually mature. Its head is small, about the size of a pin-head, and is provided with four sucking-disks and a circlet of from twenty-five to twenty-eight sharp hooklets, by which it attaches itself to the wall of the intestine (Fig. 30).

The eggs of this worm are expelled with the dejecta of the affected person. They are nearly round, and are encased in a firm shell covered with minute rods. On being extruded the eggs develop no further, unless, as is most frequently the case, they are taken up by either man or the hog. In the latter event the embryo passes into the voluntary muscles of the animal, and becomes metamorphosed into the bladder-worm, or *cysticercus cellulosæ* (Fig. 31), there to remain until

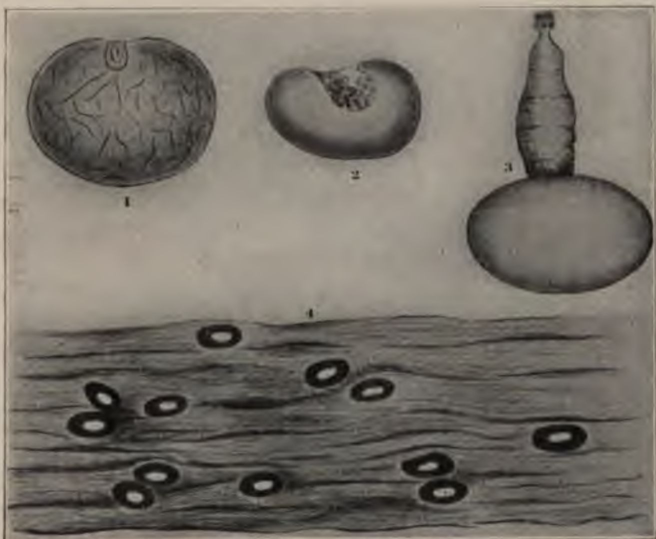


FIG. 31.—Cysticerci cellulosæ: 1, 2, 3, developmental forms; 4, in muscle (after Leuckart).

it ultimately dies or until it passes into the stomach of man with the flesh of the animal that is eaten as food. On reaching the stomach of man it develops into a mature tape-worm identical to that from which its life cycle was begun (Fig. 32). Pork affected with cysticerci is commonly known as "measled" or "measly."

It occasionally happens that, instead of the development of an intestinal worm after the swallowing of flesh containing *cysticerci cellulosæ*, the embryos pass into the muscles or viscera of man. In this event he, equally with the hog, is play-

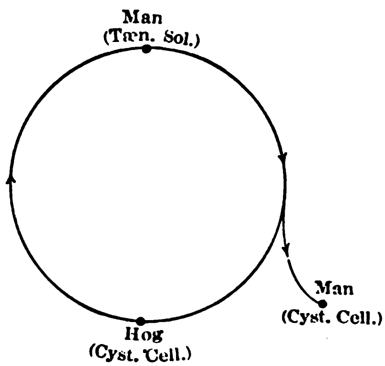


FIG. 32.—Life cycle and intermediate hosts of tænia solium (after Bollinger).

ing the part of intermediate host. Under these circumstances the larvæ do not come to maturity, but remain in the muscles

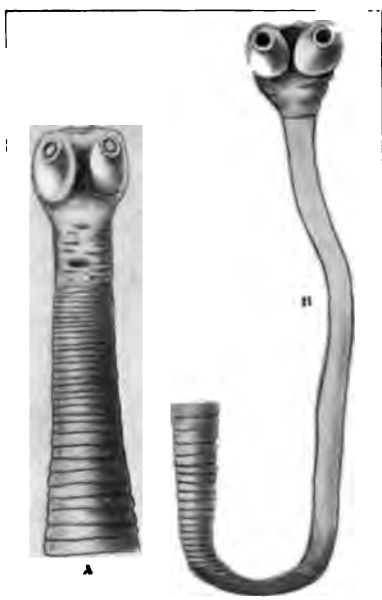


FIG. 33.—Head of tænia saginata. *A*, neck retracted; *B*, neck extended (after Leuckart).

and organs, there to cause little or no inconvenience; or, when very numerous, to give rise to more or less grave symptoms, according to their locality.

Occasionally this accident occurs in persons already supporting a mature worm, the segments of which are passed into the stomach during attacks of vomiting, there to liberate embryos that penetrate into the muscles and viscera.

Tænia Saginata or Mediocanellata (*Beef Tape-worm*).—This is the largest tape-worm encountered in man, being often as much as 20 to 25 feet long and consisting of from 1000 to 1500 segments. The mature segments measure from 17 to 20 mm. (0.7–0.8 inch) in length, and from 5 to 7 mm. (0.2–

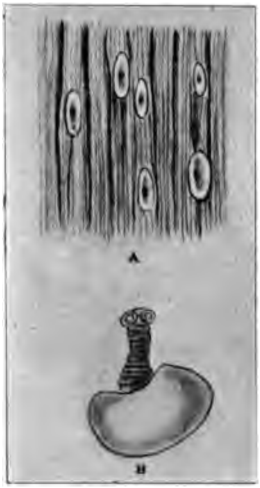


FIG. 34.—Cysticerci bovis. *A*, in muscle; *B*, developmental form; head everted (Leuckart).

0.3 inch) in breadth. The head is relatively larger than that of *tænia solium;* it is provided with four strong, prominent suckers, but has no hooklets (Fig. 33). Sexual maturity begins with about the 600th proglottide. Each mature segment is sexually complete—*i. e.*, is provided with both male and female generative organs. Development is so rapid that it is said that as many as 10 fully mature proglottides containing ova in large numbers may be ejected daily. The ova have not the power of further development when thrown off from the body, unless they are taken into the stomach of the ox; then the embryos pass into the

voluntary muscles, to remain as bladder-worms or *cysticerci bovis* (Fig. 34). Beef so infected is referred to as "measled." It is upon the eating of such uncooked "measled beef" that the larvæ of *tænia saginata* are introduced into the alimentary tract of man, there to develop into the mature worm above described (Fig. 35). The worm in beginning its growth attaches itself high up on the wall of the small intestine.

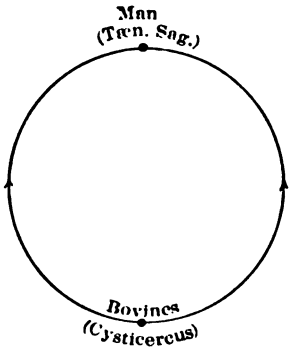


FIG. 35.—Life cycle of tænia saginata (after Bollinger).

About two to three months intervene between the time of ingestion of the larvæ of this worm and the appearance of proglottides in the dejecta.

Tænia saginata is commoner in this country than is *tænia solium*, probably owing to the greater care that is given to the cooking of pork.

Bothriocephalus latus, a large, long cestode found more commonly in those whose diet is composed of fresh fish. It is said to be common in the Baltic provinces and in parts of Switzerland. In its larval form it is often encountered in the abdominal cavity of the pike, its intermediate host, into which the embryos are believed to have penetrated from without.

The adult worm is long, measuring from 8 to 9 meters; is thin at its edges, with a central longitudinal ridge; and may be composed of as many as 3000 to 3500 segments. Its head, about 2 mm. (0.08 inch) long, is more or less conical; is without hooklets; and is marked on either side by a longitudinally grooved sucker (Fig. 36 *B*). The embryo is ciliated, is pro-

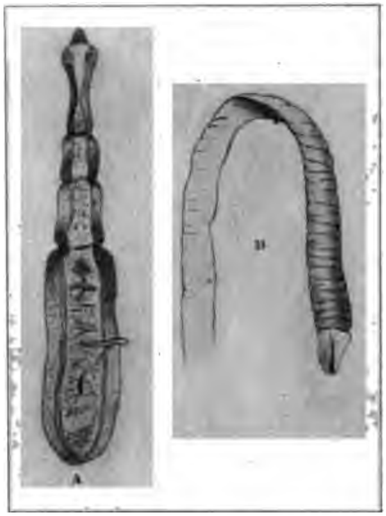


FIG. 36.—*A*, Tænia echinococcus, *B*, head of bothriocephalus latus (after Leuckart).

vided with hooklets, and is able to support itself in water for more than a week.

Feeding experiments upon man, cats, and dogs with the

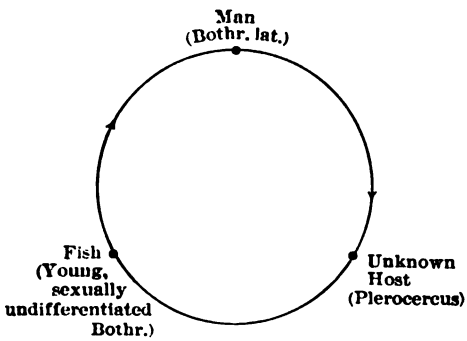


FIG. 37.—Life cycle and intermediate hosts of bothriocephalus latus (after Bollinger).

larvæ of this parasite have resulted in the appearance of the adult worm in the intestine (Fig. 37).

Tænia Echinococcus (*Echinococcus Hominis*).—Occasion-

ally man serves as the intermediate host in the life cycle of this organism. The mature worm infests the dog, wolf, and jackal. It is very small, measuring but about 5 mm. (0.2 inch) in length, and is composed of only 3 or 4 segments, the last and largest of which alone exhibits all the characteristics of sexual maturity. Its head is very small, is armed with a double-row of from 30 to 50 heavy hooklets, and is provided with four suckers (Fig. 36, *A*).

The narrow neck merges into the first, imperfectly developed, segment. The second segment is more markedly differentiated, while the third, mature, segment is seen to contain numerous eggs in which may be detected the six-

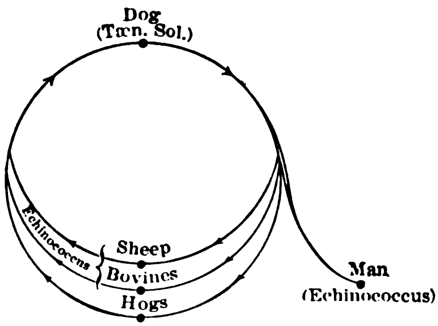


FIG. 38.—Life cycle and intermediate hosts of tænia echinococcus (after Bollinger).

hooked embryos. For the further development of the embryos after the escape of the eggs from the body it is necessary that they enter the body of some other animal—the hog, the ox, or man. Here it penetrates to the viscera, commonly the liver, and enters the larval or cysticercus stage commonly known as hydatid or echinococcus cysts. Unlike the other cysticerci mentioned, these have the power while in this larval stage of increasing both in size and number. The scolices seen within the cysts, and they are often numerous, are each the germ from which a mature worm can develop when favorable circumstances present—*i. e.*, when they gain access to the stomach of the dog (Fig. 38). The commonest and practically the only source from which echinococcus cysts are contracted in man is the dog.

SECTION III.

PROPHYLAXIS IN GENERAL AGAINST INFECTIOUS DISEASES.

INCLUDING VITAL, CHEMICAL, AND PHYSICAL PROCESSES, THE MANAGEMENT OF CONTAGIOUS DISEASES, AND QUARANTINE.

VITAL PROCESSES.

Comprising a consideration of Immunity, Natural and Acquired; the Practice of Vaccination and Protective Inoculation; and the Evolution of our Knowledge of the Antitoxic Condition.

THE living animal body is provided by nature with the means of combating more or less successfully the inroads of infective agencies. Experiment has demonstrated that there resides within the tissues and fluids of the healthy body the property of destroying disease-producing micro-organisms in large or smaller numbers. This function is especially noticeable in the serum of the circulating blood, though it may also be detected in other fluids and in the juices from the normal organs. In vigorous health it is most manifest, while the effects of malnutrition, fatigue, debauch, disease, and, in short, all influences that materially disturb the equilibrium of physiological function, are to diminish or destroy it totally. On the other hand, experiment has also shown that by particular methods special weapons of defence for use against specific invaders may be supplied to individuals from whom they are normally absent, or be accentuated in their efficiency in others in whom they are present to only a limited extent. The practical procedures by which this is accomplished are simple, though their *modus operandi* is as yet far from fully understood. They comprise those operations that are concerned in the artificial induction of vital resistance to particu-

lar forms of disease, such as vaccination, protective inoculation, and the other methods of affording immunity that are herein to be mentioned.

In the familiar observation that a single non-fatal attack of certain diseases often endows the individual with immunity from subsequent inroads of the same malady, we have the starting point for all that has been done in the important field of preventive inoculation.

This is not by any means an observation of recent date. Early in the eighteenth century it was the custom in certain parts of the Orient to induce small-pox purposely by the inoculation of healthy individuals with the matters from small-pox patients. The idea was that if such an inoculation was made from a mild case of the disease, only a mild attack occurred in the person inoculated, and that with recovery he was henceforth proof against the disease.

Prior to the introduction of vaccination by Jenner, and for a short period afterward, the practice of inoculation was in vogue in England, having been introduced into that country by Lady Montague, who had become familiar with its employment in India. Though unquestionably lives were saved by it, still, as Jenner himself testifies, much suffering was entailed, many lives were sacrificed, and the disease was often disseminated in a violent form as a result of the inoculation.

The first scientific advocacy of a method which imitates nature in affording immunity to an infectious disease, and the benefits of which were not only practically certain, but were obtained without jeopardy to life, was that of Jenner in 1798 in favor of vaccination against small-pox. Before the time of Jenner's preventive vaccinations against this disease it had been observed that after recovery from a harmless attack of an affection known as cow-pox, the individuals so affected were henceforth in most cases insusceptible to the ravages of small-pox.

For a period of more than half a century after Jenner's discoveries nothing was done to apply the principles involved in small-pox vaccination to the prevention of other diseases,

largely, perhaps, because nothing was known as to their cause, and none of them possessed such peculiar relations as had been noted between small-pox and cow-pox.

With the discoveries made about the middle of this century that certain infectious diseases depended upon a tangible cause, and the numerous additions to knowledge that rapidly accumulated subsequently, the question of vital protection again assumed a prominent place in the minds of scientific workers.

The fact that single attacks of the diseases, acquired either naturally or induced artificially, often protect the individual against a subsequent attack, naturally suggested the query respecting the cause of the phenomenon. Though this problem is still under discussion and is still far from completely solved, yet the manifold investigations of recent years upon the various phases of this many-sided subject have been most fruitful. By exact experimental methods many hitherto obscure points have been elucidated; and though much remains to be done, we can, nevertheless, speak with a fair degree of confidence upon many of the important features of the subject.

In the early studies in this field the ideas that were advanced in explanation of immunity and susceptibility belonged largely to the realm of the hypothetical. They were without foundation in truth and when tried in the balance of experimental test were found to be sadly wanting. From the time of Jenner's demonstration, in 1798, to the effect that it was possible to protect human beings against small-pox by vaccination with the lymph obtained from the cow-pox vesicle—a phenomenon of the intimate nature of which we know little more now than he did then—up to 1880, nothing was contributed to our knowledge of the subject. In 1880, in the course of his studies upon the cholera of chickens, Pasteur[1] showed, for the first time, that by artificial means it was possible so to modify the virulence of the bacteria causing this disease that they would no longer produce fatal results, but, instead, only temporary local dis-

[1] *Comptes rendus, Acad. des Sci.*, 1880, tome xci., p. 673.

turbances, and that in these cases the chickens that had recovered from such a modified attack were not now susceptible to the inroads of the highly virulent bacteria that cause the fatal form of the infection.

In view of the fact that about the same date (1878–81) Pasteur, Koch, Toussaint, and others had proved the rod-shaped organisms discovered by Pollender (1855) and by Davaine (1863) in the blood of animals dead of anthrax to be the etiological factors concerned in this disease, it is not surprising to find the observations of Pasteur utilized in a scheme for the production of a vaccine against this much dreaded disease, and as a result of numerous trials by different experimenters, it was ultimately demonstrated that by the employment of various agencies, thermal and chemical, drying and prolonged cultivation under particular artificial conditions, it was possible to do to the virulent anthrax bacillus just what Pasteur had done to the bacillus of chicken cholera—namely, to so attenuate its virulence that it no longer killed susceptible animals, but caused instead only temporary disturbances from which the animals recovered. With recovery they were usually found to be no longer susceptible to the more severe, commonly fatal, form of the infection. We can justly say that it was in the course of these studies on anthrax that the foundation stones were laid for our knowledge of protective vaccination with attenuated living virus.

Living vaccines capable of protecting animals more or less completely against fatal infections have from time to time been prepared by subjecting the virulent organisms that cause the disease to a variety of detrimental agencies—namely, by exposing them to the unfavorable conditions that are active in the body of an insusceptible animal; by cultivating them under artificial circumstances in nutritive media containing various hurtful chemical agents in such strength as not to kill, but rather to interfere only with the full development of their normal physiological functions; by cultivating them in normal nutritive media, but at a temperature somewhat higher than that which is compatible with

vigorous growth; by subjecting them for a short time to a temperature that would prove fatal if its action were long continued; by drying; by exposure to direct sunlight, to electricity, to high pressure, and in short, by any of the manifold deleterious influences that may be so regulated as to retard development without actually destroying the organism.

Living vaccines, prepared by some one or other of the foregoing procedures, have been employed experimentally and in practice with varying degrees of success for the purpose of protecting animals, and in two instances man, against a number of infectious diseases, notably anthrax, symptomatic anthrax, swine erysipelas, pleuropneumonia, diphtheria, glanders, pneumococcus infection, Asiatic cholera, and rabies (the last two in man also). In no instance has their use been as general or the results as satisfactory as in the case of anthrax.

Of fundamental importance to our understanding of the processes of immunity is the fact that the constitutional symptoms and pathological lesions of disease are the results of the toxic activities of metabolic products of the bacteria concerned in the production of disease, and that immunity, as well as disease, is established by these substances, not alone when elaborated within the tissues of the animal to which the bacteria have gained access, but also when they are produced under artificial conditions of cultivation and purposely introduced into susceptible animals.

An advance of great importance was made in our knowledge of immunity through the application of this fact by Salmon and Smith.[1] They demonstrated that a certain sort of immunity to particular forms of infection might be conferred upon animals by injecting into them the filtered, germ-free products of growth of certain bacteria to the pathogenic influences of which the species of animal under treatment was highly susceptible.

[1] *Proc. Biolog. Soc.*, Washington, D. C., 1886, vol. iii.; *Centralbl. für Bakt. und Parasitenkunde*, 1887, Bd. ii.; *Trans. IX. Internat. Med. Congress*, Washington 1887.

This demonstration of the possibility of inducing immunity through purely chemical, or biologico-chemical, means shed an entirely new light on the subject. As a result of numerous investigations suggested by this discovery, immunity is to-day held by a number of those who have had most to do with the elaboration of our knowledge of it as a purely chemical phenomenon, a phenomenon that involves not the micro-organisms themselves that are concerned in the production of disease, but rather the agencies through which they produce it—namely, their poisons.

It was subsequently demonstrated that if the poisonous products of growth of certain pathogenic bacteria be introduced into the body of a susceptible animal in non-fatal doses, or in a condition of diminished toxicity, that the effect of such treatment is exhibited by a more or less pronounced constitutional reaction on the part of the animal. After recovery from this temporary disturbance, the animal is often found to be not only insusceptible to infection by the bacteria by which the poison was manufactured, but the serum of its blood in certain cases has undergone a demonstrable change: It has acquired the property of neutralizing the fully virulent poisons, though its property of destroying the bacteria themselves may not in all cases have been conspicuously altered. In other words, in the process of acquiring immunity the chemical composition of the blood is modified; it is enriched by the addition to it, through changes in the body, of a substance that is antidotal to the poisonous products of the pathogenic bacteria against which the animal is immunized, without its relation to the bacteria themselves having been in all cases materially changed.

In this connection it is important to note that it is possible by the repeated injections of non-fatal but gradually increasing doses of toxins into susceptible animals to increase finally the antitoxic value of the blood of that animal to a degree far in excess of that ever seen to exist in immunity acquired through an ordinary attack of disease, or the immunity that is induced simply as a prevention against bacterial invasion. It is in this way that antitoxic serums are obtained that are

of sufficient strength—that is, contain sufficient amount of the antidote, to be of service in the treatment of disease already in progress, a condition necessitating the neutralization of large amounts of poison circulating in the body as speedily as possible with the greatest amount of antidote concentrated in the smallest bulk of the curative agent.

In the course of earlier investigations upon the subject, Buchner[1] offered the suggestion that the immunity conferred by a single attack of disease exists by reason of certain "*reactive changes*" that occur in the tissues during the disease, and that with the establishment of this alteration the animal acquires insusceptibility to further attacks of the same malady. Though much has been done on the subject since this hypothesis was advanced, we are to-day but little nearer the actual solution of the problem than that which is embodied in this view.

The opinion now generally held is that the tissues acquire, during the constitutional reaction coincident with the primary attack of the disease, the property of generating the antidotal substance, though it is also believed, especially by Buchner, that the antidotal or antitoxic body is in some cases the poisonous products themselves of the bacteria so modified through the reaction of the tissues that they now possess protective, neutralizing, or antitoxic peculiarities. On these points, however, there are diverse opinions, and it is as yet impossible to speak with certainty.

The observation that the serum of the blood of a susceptible animal could be rendered antidotal to certain bacterial poisons by the gradual introduction into the animal of the poisons until a condition of tolerance was reached, together with the discovery that a certain group of highly pathogenic bacteria produce their effects almost, if not entirely, through poisons that they produce within the system, while they themselves are localized to some particular point within or upon the body, suggested a line of experiments having for their object the practical application of these observations to

[1] "Eine neue Theorie über Erzielung von Immunität gegen Infektionskrankheiten," Muenchen, 1883.

the treatment of disease resulting from the activities of what may be termed the truly *toxic* pathogenic bacteria. It was in the course of these investigations that Behring and Kitasato [1] made the important discovery that the serum of the blood of animals rendered tolerant to certain bacterial toxins not only afforded protection to these animals against the poisonous effects of these substances through antidotal properties, but that by the transference of serum from this immunized animal to another susceptible animal, that immunity was at once conferred upon the animal into which such serum had been injected. The original observation was made in the course of studies upon tetanus.

It was not long, however, before the principles upon which this observation rested were applied to the study of other forms of toxic infection, with the result of placing in our hands, through the labors of Behring and his associates, an agent whose favorable influence upon the course of the diphtheritic infection is so pronounced as to justify the opinion that with the introduction of the antitoxic serum to the treatment of diphtheria, an epoch was marked in the history of medicine.

By some the method of inducing and transferring immunity, as elaborated by Behring and his colleagues, is considered as only the induction of a condition of tolerance to chemical poisons—*i. e.*, the rendering of an animal poison-proof (Giftfest), and not as a protection to bacterial infection. There is evidence, however, to indicate that this view is erroneous, and that the method is applicable in certain cases of true infection that are not characterized by marked toxic features.[2]

In the present state of our knowledge it is impossible to say to what extent acquired immunity in human beings is due to the presence of antitoxic substances in the circulating fluids, or to indicate in how far the observations that have been made upon tetanus and diphtheria are applicable to

[1] *Deutsche med. Woch.*, 1890, Bd. xvi., S. 1113.

[2] Consult Kitt: *Centralbl. für Bakt. und Parasitenkunde*, 1893, S. 869; Lorenz: *Ibid.*, 1893, S. 357, and 1894, S. 278.

other infections; certainly, in so far as the truly toxic infections are concerned, one is constrained to feel sanguine as to the ultimate outcome of the further application of the principles on which the antitoxic method of treatment is based. As a precautionary measure, however, it may not be amiss to emphasize the impropriety of generalizing from these single instances. We must bear in mind that the conclusions reached with regard to tetanus in animals, and diphtheria in man, are the results of observations having an incontestable experimental basis, without which any pseudoscientific structure that we may rear through analogical reasoning will, sooner or later, totter and fall without a moment's warning. The wider application of these principles to the treatment of disease is only to succeed through the establishment of a firm basis of experimental proof for each separate and distinct affection. From this it is clear to those who are familiar with laboratory methods that there are many obstacles to be overcome, some of them in our present position, almost insurmountable. The impossibility of faithfully reproducing in animals that we use for experiment some of the most important diseases to which human beings are liable, may serve as an example of one of the gravest of these difficulties.

From what has preceded, we observe that we must distinguish between three principal methods of inducing immunity—namely, by the activities of living bacteria in the tissues—*i. e.*, by living vaccines; through the introduction into the body of the germ-free, poisonous products of bacteria; and through the introduction into susceptible animals of the serum of the blood (and other secretions) from another animal already immunized.

By either the first or second of these procedures the condition of immunity is established only after the lapse of the time necessary for the elaboration of the immunizing substances within the tissues; whereas, by the last method these substances that have already been prepared in the immunized animal from which the serum is obtained are transferred directly, and the animal receiving them is at once protected;

as Ehrlich[1] conceives it, one simply transfers the protecting agent from one animal to another.

There is a further distinction as regards the results of these methods of procedure. The immunity that is induced through vaccination with attenuated living virus, or conferred by the gradual introduction of toxins to the point of tolerance, simulates more closely in the degree of its permanence the immunity usually conferred by a non-fatal attack of infection contracted in the ordinary walks of life than does that produced by the injection of the serum of immunized animals.

Ehrlich[2] proposes to designate the more or less permanent immunity frequently conferred by an attack of an infectious disease as "active immunity," while for the immunity that is established through the direct transference of the immunizing agent from the blood of one animal to the tissues of another he employs the name "passive immunity." This designation is not acceptable to all writers on the subject, the objection being that there is not as yet sufficient proof that the induction of "passive immunity" is as simple a matter as Ehrlich conceives it to be. There is some evidence in support of the idea that the real immunizing agent may not be contained in the immunizing serum, but that this serum is only instrumental in inducing the peculiar tissue-reaction that results in the formation of the actual protecting body.

Another point in connection with this subject, on which there has been considerable controversy, is that concerning the *specificity* of the relation between the immunity-inducing toxins and the antitoxic substances elaborated in the body as a protection against them. By the majority of investigators there is believed to be a specific antagonism between the poisons produced by a given infectious micro-organism and the protective agent that is present in the body of the animal artificially immunized against this particular micro-organism. Objections have been raised to accepting this as a law, on the grounds that the serum of artificially immunized animals is

[1] Ehrlich: *Deutsche med. Woch.*, 1898, Nos. 32–44; *Zeit. f. Hyg. und Infektionskrankheiten*, 1892, Bd. xii., S. 183; —— and Hübener: *Ibid.*, 1894, Bd. xviii., S. 51.

[2] Loc. cit.

sometimes seen to possess protective properties, to a limited extent, against forms of infection or intoxication other than that against which the animal has been protected. In this connection, it must be remembered that the *normal* serum of man, of horses, and occasionally of other animals, has also at times been observed to possess similar "*general*" antitoxic peculiarities. It may be that the observations on which are based the objections to the idea of a specific relation between particular toxins and their antitoxins can be explained through this normally present, universal, so to speak, antidote.

In a number of experiments, antitoxic properties of the serum against specific bacterial poisons have been induced through the induction of tolerance to the poisons of bacteria of a different species. This condition appears, however, to be little more than an accentuation of the normally present protective agent already referred to. It has never been possible to bring about in this manner as high or as permanent a degree of immunity against a particular disease as that which can be obtained by the use of the specific micro-organism causing the disease, or the products of its growth.

Of fundamental importance in their bearing upon this subject are the remarkable observations of Pfeiffer.[1] He showed that it was easily possible to confer upon guinea-pigs a condition of immunity to Asiatic cholera by the repeated injections into them of sterilized cultures of the organism causing the disease. If upon the establishment of immunity he now injected into the peritoneal cavity of these animals an amount of the living culture that would otherwise certainly prove fatal, not only had this no effect, but within a few minutes, almost instantly, there was an actual disintegration of the organisms injected that could readily be followed with the microscope. He demonstrated, further, that this relation between the immune animal and the organisms against which it was protected was a specific one, and that no such disintegration occurred when other bacteria were injected. If, with the cholera spirillum other bacteria were injected, *only* the chol-

[1] *Zeit. f. Hyg. und Infektionskrankheiten*, Bd. xviii., S. 1; *Ibid.*, Bd. xx., S. 198.

era spirillum was thus broken up. He showed, in addition, that while the serum of the blood of the immune animal was capable of conferring immunity from Asiatic cholera upon other animals not immune, it had no disintegrating effect upon the cholera spirillum when in contact with it in the test-tube, but if he injected into the peritoneal cavity of a non-immunized guinea-pig the fatal dose of living cholera spirillum, and followed this immediately by an intraperitoneal injection of the serum from an immune animal, *at once* the disintegration of the bacteria within the peritoneal cavity was to be detected.

It will be seen that these investigations are of importance, not alone as regards the question of specificity, but also as regards the nature and origin of the protecting body, for we have here a serum from an immune animal capable of conferring immunity—capable, when injected into the susceptible animal, of endowing it with the peculiar germicidal function noted in the immune animal from which the serum originated, but still, totally incapable of this remarkable bactericidal activity when tested outside the animal body. Manifestly, the real protective agent is generated by the tissues as a result of the specific irritation of a something contained in the serum.

Applying this principle in part to certain other infectious diseases, it has been shown that the serum from cases of typhoid fever when brought in contact with pure cultures of the typhoid bacillus outside the body has the property of arresting its motility and causing the individual cells to arrange themselves in clumps, a condition never seen in normal cultures of this organism and a condition that is seen only when typhoid bacilli and typhoid serum are in contact. It does not occur when other organisms are used, nor, so far as experience goes, does it result from the use of other serums with this organism.

We must remember, however, that our knowledge on this subject does not as yet admit of the laying down of hard and fast laws, and it is not unlikely that much of what we consider as sound to-day may to-morrow prove to be untrustworthy. We are in many respects hardly more than on the threshold of this many-sided subject.

Equal in interest and importance to any of the other problems relating to the question of acquired immunity, is that concerning its transmissibility from parent to offspring. Can the condition of acquired immunity from particular infections and intoxications be inherited?

While there have arisen from time to time examples that serve to indicate the possibility of this question being answered in the affirmative, we are indebted to Ehrlich [1] for the experimental demonstration of the accuracy of these indications. In the course of a series of studies upon the vegetable toxalbumins, abrin, ricin, and robin, especially as regards their intoxicating effects upon animals, and the methods of inducing immunity from them, he demonstrated the possibility of easily inducing in white mice, normally markedly susceptible to these poisons, a condition of resistance that enabled them to withstand large multiples of the otherwise fatal dose. He likewise conclusively demonstrated that females on whom such immunity had been conferred transmitted, through the milk, to their nursing young, an antitoxic substance that induced in them a condition of body through which they, too, were enabled to resist the otherwise fatal dose of the particular poison against which the mother was immunized. This transmission of immunity appears to be entirely a maternal function, the father, in Ehrlich's experiments, playing no part in the process.

From the preceding considerations of the subject we see that a condition of immunity from certain forms of infection may be more or less easily acquired, and that, when once acquired, it may be in some cases conferred upon the young during the nursing period, through the milk of the mother. But there is no positive proof that such conferrence occurs during intra-uterine life.

In the light of these established facts, one might be tempted to consider the *natural* immunity possessed by certain individuals and species from particular forms of disease as, after all, an acquired trait—acquired not as a result of the purposeful inoculation of progenitors with modified virus or

[1] Loc. cit.

attenuated toxins, but rather acquired through the processes of survival and hereditary transmission. For instance, one might argue that when a given number of individuals become affected with the same form of infection, those that survive are manifestly not only less susceptible to its inroads than were those that succumbed, but, as we have seen, the degree of this insusceptibility is further increased by the attack of the disease through which they have safely passed. These survivors, it might be claimed, transmit to their offspring not only certain mental and structural characteristics, but physiological peculiarities as well, among which may be a condition of insusceptibility to this particular form of infection that has been accentuated at the nursing period through the protecting influences of the milk of an immune mother. Still, in support of this view one might continue: the constant presence in a community of a certain form of disease is ultimately accompanied by a diminution of its virulence and a lower degree of fatality from it than is seen to follow its first or only occasional appearance, and that continuous exposure, therefore, of large numbers of individuals to particular diseases may result, through the natural phenomena of survival and inheritance, in developing a race endowed with *natural insusceptibility* to this malady.

Plausible and attractive as this view may appear on superficial examination, there are objections to its adoption.

In the strict sense of the word, and in the light of present knowledge, we must regard *natural immunity* as a trait that has been transmitted, and is further transmissible, through generations by parents in whom it is blastogenic. It is congenital, therefore, and inherent to the integral protoplasm of the individual or species endowed with it. There is no evidence of its having been acquired through any of the channels that apply to the acquisition of immunity. Its transmission, like other physiological peculiarities, is probably as much under the paternal as the maternal influence, and is lasting; whereas, the transmission of acquired immunity is a function only of the mother and, so far as we know, is of but temporary duration.

There can be no doubt that the constant exposure of a race of individuals to a disease ultimately results in a diminution of susceptibility of many of the individuals to this disease. It appears to be more logical to consider this condition of "acclimatization," as it is popularly called, from two standpoints—namely, with regard to the individual, and with regard to the race. Where it concerns an individual it is either *natural*, in the sense of the word "natural" as here used—*i. e.*, an idioplasmic characteristic, or is *acquired*, as a result of an attack of the disease through which the individual has safely passed; where it concerns a race it appears to be much more likely that it has evolved as a result of the survival and multiplication of those individuals of the race who were by nature—*i. e.*, congenital—either completely or partly insusceptible, their susceptible fellows having gradually been exterminated.

It may be safely said that probably no human race is, as a whole, immune from any disease of man. Nevertheless, in every race there may be encountered individuals who are more or less immune to this or that disease; and with regard to the relation of certain races to particular diseases the proportion of such individuals may be conspicuously high.

Still further in favor of the idioplasmic origin of this peculiarity of *natural immunity*, and in opposition to its acquisition by exposure to disease, is the fact that even among these races which, through constant exposure to particular diseases, have become "acclimated," the newly born do not from birth partake, as a rule, of the peculiarity, and usually become insusceptible only after having had the disease. A striking illustration of this is offered by the Creole populations in yellow-fever districts. While not totally immuned from the disease, the Creoles are, as a race, much less susceptible than their white brothers, and yet, on the authority of Guitéras, "the foci of endemicity of yellow fever are essentially maintained by the Creole *infant* population." Manifestly, the relative insusceptibility of the Creole to this disease is not a race characteristic, but is rather one that the individual acquires for himself only with recovery

from the disease. The increase of tissue-resistance acquired in this way cannot be regarded as natural immunity in the sense in which the term is now generally understood.

To admit that the condition of natural immunity represents, after all, the inheritance of an induced peculiarity, is to admit in general the possibility of the hereditary transmission of acquired traits, "an assumption that has often been made, but never yet proved."[1]

Natural immunity must as yet be considered as a vital property, inherent to the idioplasm, the intimate nature and workings of which cannot be explained. It distinguishes the individual endowed with it only by its protective influences during exposure to particular forms of disease. It is not explainable through any demonstrable excess of protective characteristics of the body-fluids or tissues, contrary to what may usually be done in the case of artificially immunized animals, for, as stated above, the fluids of the body of the naturally immune animal may be neither more nor less germicidal or antitoxic than are similar fluids from animals that are naturally susceptible.

Manifestly, the prevention and treatment of disease along the lines suggested by the investigations here cited in many respects closely simulate some of the methods of nature. It is from this standpoint that we believe the further elaboration and wider application of the principles involved in the processes of preventive inoculation and serum therapeutics are destined to be of inestimable service in the advancement of the preventive and curative medicine of the future.

Already as a result of these labors, animals have been rendered more or less insusceptible to a number of different infections and intoxications—for instance, to chicken cholera, anthrax, erysipelas, symptomatic anthrax, malignant edema, hog cholera, typhoid fever, hemorrhagic septicemia, vibrionic septicemia, Asiatic cholera, diphtheria, tetanus, pneumococcus infection, pyocyaneus infection, proteus infection, infection or

[1] Weismann, "Essays on Heredity and Kindred Biological Problems;" "Essay on Retrogressive Development in Nature," vol. ii., p. 14. Edited by Poulton and Shipley, Oxford, Clarendon Press, 1892.

intoxication by *bacillus coli communis*, and infections by pyogenic cocci.

Not only has the possibility of conferring immunity to these infections been demonstrated, but in the case of certain of them the serum of the blood of the immunized animals has been found to possess properties that can be utilized in the treatment of these infections or intoxications after they are already in progress in other animals. Thus, for example, the treatment of diphtheria by the antitoxin method comes under this head. In the case of erysipelas, the experiments of Marmorek[1] and others indicate similar possibilities. Marmorek found in the blood of rabbits immunized from infection by the streptococcus of erysipelas, a substance that he states possesses curative powers over the disease when it is already in progress in non-immunized animals. Pfeiffer and Kolle[2] have detected in the blood of animals rendered tolerant to the typhoid toxin a substance that is germicidal to the typhoid bacillus, and Beumer and Peiper[3] find a non-germicidal, but rather an antitoxic substance in the blood of animals artificially immunized from the typhoid poison. Beumer and Peiper state that this serum possesses not only immunizing powers, but that the poisonous effects of the typhoid toxins can be neutralized by the subsequent injection of the antitoxic serum. They believe, therefore, that the serum possesses curative virtues. Yersin, Borel, and Calmette,[4] in their studies upon bubonic plague, obtained from the blood of animals rendered immune from this infection an actively antitoxic serum that they hope to utilize ultimately in the treatment of the disease. The studies on vaccinia lead to the belief that there exists in the blood of the vaccinated animal a substance possessing certain antagonistic relations to the active principle of vaccine lymph,[5] whatever that may be. In this case, as with

[1] *La semaine méd.*, 1895, No. 17; *Annales de l'Inst. Pasteur*, 1895. tome ix.; consult also Roger: *Ibid.*

[2] *Deutsche med. Woch.*, 1894, No. 48.

[3] *Zeit. f. klin. Med.*, Bd. xxviii., Hefte 3 and 4.

[4] *Annales de l'Inst. Pasteur*, 1895, No. 7.

[5] For literature on this subject consult Sternberg and Reed: *Trans. Assoc. of Amer. Phys.*, 1895, vol. x., p. 57.

scarlatina, both experiments and results are unsatisfactory, because of the important unknown factors that come into play. From recent investigations it seems probable that the treatment of tetanus by means of antitoxic serum, as is shown to be possible in animals, will, before a very great while, be successfully extended to the disease in men. The treatment of Asiatic cholera by the antitoxin method is apparently destined to be an outcome of the very near future, and finally, the experiments bearing upon the treatment of tuberculosis by means of antitoxic substances is predicted by Behring to be soon successfully demonstrated. Behring and Knorr[1] already claim to have detected in the blood of animals rendered tolerant to the poisonous influences of tuberculin (the toxin produced by *bacillus tuberculosis*), a body, antituberculin, that possesses the property of robbing tuberculin of its poisonous peculiarities.

When we contemplate this array of practical results and bear in mind that they are the outgrowth of experiments made with a definite purpose, each step of which was directed toward a particular object, and that through these experiments susceptible animals—and, in a few instances, man—have been, and may at will be, rendered more or less immune from a number of diseases of bacterial origin, there is justification for the statement "that the problems relating to immunity and infection have been, in part at least, removed from the realm of pure hypothesis and placed in a position favorable to exact experimental solution" (Welch).

[1] Behring: Address delivered before the 67th meeting of Naturalists, at Lübeck—*Deutsche med. Woch.*, 1895, No. 38.

CHEMICAL AND PHYSICAL PROPHYLACTIC MEASURES.

WE have already learned that there is thrown off from the body in the course of transmissible diseases substances which, if not destroyed, possess the power, under favorable circumstances, of disseminating these maladies. In some instances such infective agents are contained in the secretions from the mouth, throat, and nose, as in diphtheria and whooping cough; in others they are present in the matters spat up from the lungs, as in pulmonary tuberculosis, influenza, and pneumonia; again, they are present in the vomited matters and evacuations from the bowels, as in cholera, typhoid fever, and tropical dysentery; while in still other cases they are discharged through lesions of the skin consequent upon subcutaneous suppurations, or from the surface of the skin itself, as during the desquamation period of the acute exanthemata.

We have also learned that the majority and the most important of the factors directly concerned in the causation of specific communicable diseases are living micro-organisms—bacteria—and that as they are expelled from the infected individual they are often associated with other bacterial species that are concerned in disease-production—*i. e.*, with the innocent varieties usually present in the mouth, the intestines, and the skin.

In many instances these infective micro-organisms find conditions outside the body that are not at once detrimental to their vitality and pathogenic activity; indeed, under particular enviroment they are capable of increase and multiplication and of becoming the source from which the disease may be disseminated through large groups of susceptible individuals. With the view of preventing such accidents disinfection and isolation are practised.

Disinfection.—Strictly speaking, the term disinfection signifies the destruction of *infective* agents, but by the methods of disinfection commonly in use, there is no discrimination made between the various species of bacteria, and all living micro-organisms, innocent as well as infective,

fall victim to the germicidal activity of approved disinfectants.

The terms disinfectant and germicide have, therefore, become synonymous by usage, and in this sense a disinfected mass is one in which all living micro-organisms have been killed.

It seems proper at this place to define the precise meaning of several terms that are used in connection with the various methods that are employed against the development of bacteria and for the suppression of their malodorous metabolic products. Such definitions become necessary because of the frequent misunderstanding of the meanings of the terms and of the principles involved, and because of the confusion that arises from their indiscriminate and inaccurate use. Briefly then, a *disinfectant* or germicide (the terms as stated are, by usage, synonymous) may be defined as a substance that kills bacteria and their spores; an *antiseptic* is a substance that is antagonistic to the growth of bacteria without of necessity killing them; while a *deodorizer* may be either a disinfectant or an antiseptic, or neither, but simply a substance having the power of destroying or masking odor, without regard to either destruction of the micro-organisms that cause it or the arrest of their development.

In the practice of disinfection there should be maintained a tolerably fixed relation between the amount of a given disinfectant used and the mass of matter to be disinfected—*i. e.*, the number of bacteria to be killed. If this ratio be not observed there is either an excess of disinfectant or there is a scarcity; in the latter event disinfection is incomplete.

The majority of disinfectants have the property of preventing the development of bacteria, even when employed in solutions very much weaker than would be necessary for disinfection; that is, in these smaller quantities they exhibit antiseptic functions. Many antiseptics have no disinfectant or germicidal properties whatever. This is true of many of the weaker vegetable acids, of a number of aromatic bodies, of sugar, and of sodium chloride.

When added to undecomposed matters both disinfectants

and antiseptics prevent decomposition and putrefaction, and, consequently, the evolution of bad odors, but when decomposition is well advanced there are few, if any, of the trustworthy disinfectants that have the property of completely destroying bad odors. Many compounds are used for this purpose, but, as a rule, their employment amounts to little more than the substitution of one odor for another.

There are a great many substances that are possessed of germicidal properties, though the list of those worthy of confidence, and hence of those in common use, is comparatively small.

For convenience of description the modes of disinfection here described will be classified as chemical and physical.

Chemical Disinfection.—By chemical disinfection we understand the destruction of the vitality of living micro-organisms, through the use of chemical compounds. In its practical application the disinfectant is mixed with or applied to the mass or article to be disinfected, in such proportions and after such a manner as experiment has dictated to be most favorable to the accomplishment of the desired result.

In many cases it is not possible to explain the *modus operandi* of disinfection, any more than to say that the micro-organisms are poisoned by the disinfectant, though in particular instances this is accomplished by a union between the disinfectant and the protoplasm of the bacteria; in others there seems to be a coagulation of the albuminoid constituents of the bacteria, while in others disinfection succeeds through the disintegrating influence that the disinfectant has upon the bacteria.

The essentials of a useful and trustworthy chemical disinfectant are:

1. It shall be a germicide—*i. e.*, it shall possess the property of destroying bacteria and their spores.

2. It should be so constituted that its germicidal properties are not destroyed by the extraneous matters in which the infective micro-organisms that are to be killed are located.

3. With ordinary care it should not be dangerous (directly poisonous) to those who are to use it.

4. It should, if possible, be without disagreeable odor; it should be cheap in price, easy to manipulate, and for particular purposes should not cause permanent stains or be destructive to the skin, to fabrics, or to other articles on which it is to be employed.

The entire list of chemical preparations that possess more or less germicidal properties is too long to introduce in a book of this size. It will suffice to mention only those that may be regarded as of the greatest general usefulness.

Sulphur Dioxide; Sulphurous-acid Gas, SO_2.—Until within a very short time there was probably no gaseous disinfectant that was more commonly used, or which enjoyed a greater degree of confidence than did the fumes arising from the combustion of sulphur. Its principal employment has been for the fumigation of apartments, wards of hospitals, ship-cabins and -holds, etc.

Modern investigations have, however, shown that the usefulness of this gas for the purpose of disinfection is comparatively limited. In the dry state it possesses little penetration, does not destroy spores, and is uncertain in its action even upon non-spore-forming organisms. The amount of it that is at all reliable should not be less than 4 per cent. by volume of the air-capacity of the room, and this should be maintained for from twelve to twenty-four hours—a condition very difficult to meet when we remember the practical impossibility of so sealing all cracks, pores, and openings of a room as to prevent diffusion.

Its efficiency is markedly increased when the objects to be disinfected are moist, a condition that may in part be met by spraying with water or by generating steam at the same time that the gas is being evolved. Upon moist objects its germicidal powers are comparatively marked for those micro-organisms that do not form spores, but even here the materials to be disinfected must be freely exposed to its action.

In the practical use of this gas as a disinfectant the following precautions are to be observed, otherwise its employment is useless:

All visible cracks, crevices, and openings of the room to be

disinfected should be carefully closed with strips of adhesive paper or with putty. To obviate accidents from fire, while the sulphur is burning, a tub half filled with water should be placed in the center of the room; two bricks are to be stood on end in it, and on the top of these is to rest the pan in which the sulphur is to be burned. Into the pan is to be placed sulphur in the proportion of 3 pounds to each 1000 cu. ft. of air-space in the room. The objects in the room are then to be moistened either by spraying with a hand-atomizer containing water, or else by condensed steam generated from boiling water. Finally, a little alcohol is poured over the sulphur in the pan, lighted, and the door of the room closed and kept closed for twenty-four hours. At the end of this time doors and windows are thrown open and the room thoroughly aired. The danger from fire may be eliminated by using compressed sulphur dioxide instead of the gas obtained by burning sulphur. The gas may be obtained from the dealers in a liquefied state (liquefied by pressure) in metal cylinders provided with valves for its liberation. These cylinders may either be placed in the room and the gas *slowly* liberated, or they may be placed in an adjoining hallway or room and the required amount of gas conveyed into the infected room by a tube passed through the keyhole of the door. After the room has been kept closed for the necessary time, the usual cleansing operations may be begun. All objects, such as pillows, mattresses, bundles, clothing in closets, chests, etc., should be disinfected by steam.

Chlorine and *bromine* possess marked disinfecting properties. Like sulphurous-acid gas, however, they exhibit their highest germicidal peculiarities only upon moistened objects. They are not in general practical use, for the reason that they are more or less destructive to fabrics, tissues, etc., but more especially because of their very irritating and sometimes dangerous action upon the respiratory apparatus of those who are using them. In the gaseous condition they are not to be recommended for general use.

Formaldehyde, Formic Aldehyde, Formalin, etc.—Formal-

dehyde, the vapor resulting from the slow (incomplete) combustion of methyl alcohol under access of air, is the aldehyde of formic acid; or, in other words, it is an alcohol of the marsh-gas (methane) series from which hydrogen has been extracted by oxidation. The position of formaldehyde in the series of products that result from the oxidation of marsh gas is as follows:

Marsh Gas, Methane.	Methyl Alcohol.	Formaldehyde.	Formic Acid.
CH_4.	CH_4O.	CH_2O.	CH_2O_2.

When formaldehyde gas is dissolved in water to about the point of saturation, we have the proprietary solution known commercially as *formalin*. Formalin represents a solution of formaldehyde gas in water of the strength of from 35 to 40 per cent. by weight. For practical purposes of disinfection this body is employed both in its pure gaseous state as formaldehyde, and in its watery solution as formalin.

FIG. 39.—Lamp for generating formaldehyde from methyl alcohol.

The active gas as used for purposes of disinfection is obtained in several ways—viz., by the slow combustion of methyl alcohol in lamps especially constructed for the purpose (see Fig. 39); by liberating it from its watery solution under the influence of high temperature, in especially constructed autoclaves

and generators (Figs. 40–42); and by decomposing its solid polymerized form in open vessels through the action of heat (Fig. 41). The various forms of apparatus on the market for the purpose are fully described in the circulars issued by their several makers.

Since the discovery that formaldehyde vapor possesses very marked germicidal properties it has been subjected to

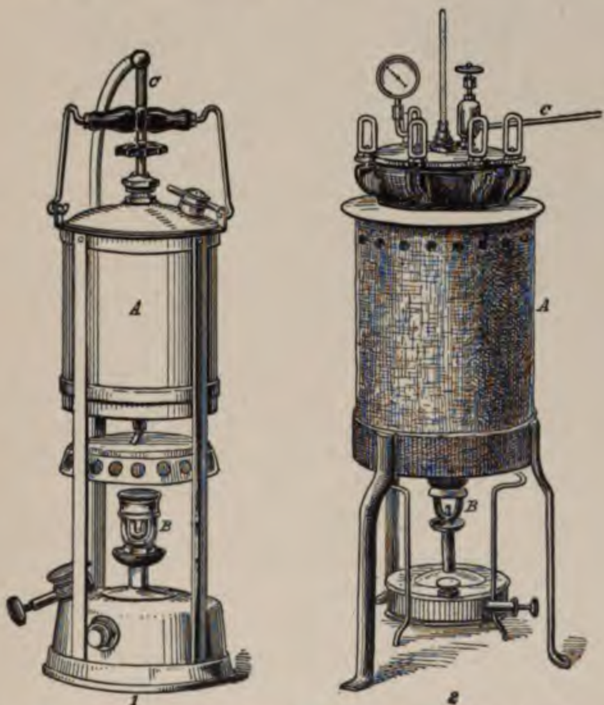


FIG. 40.—Autoclaves for generating formaldehyde (1) from formalin and (2) from formochloral: *A*, chamber for reception of the fluid; both chambers are hermetically sealed when apparatus is in operation; *B*, lamp for supplying heat; *C*, tube for conducting gas from generator into the room to be disinfected.

most careful study in this connection, by a number of competent investigators; and though the results have been in some respects discordant they agree in certain essential points —viz., that formaldehyde obtained by either of the several processes in common use is a gaseous disinfectant of high

order for the surfaces of rooms and for contained objects

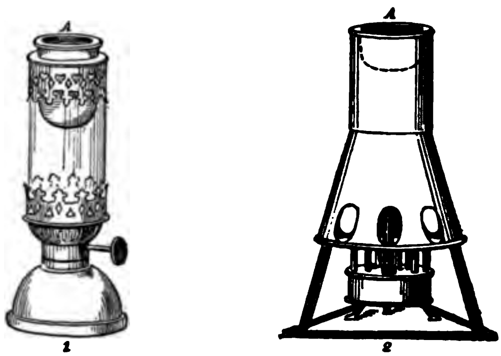


FIG. 41.—Apparatus for generating formaldehyde from tablets of polymerized formaldehyde: 1, small form; 2, for larger quantities; *A* in each figure indicates the cup in which the tablets are placed.

when the latter are freely exposed to its action; that it quickly

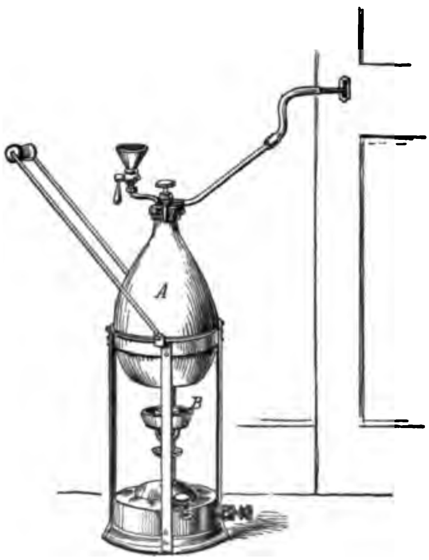


FIG. 42.—Modified Novy-Waite formaldehyde generator: *A*, retort for containing formalin; *B*, lamp for supplying heat; *C*, tube for conducting gas from retort into room to be disinfected.

destroys not only the less-resistant, non-spore-forming patho-

genic bacteria, but the more highly-resistant spore-formers and their spores as well; that to accomplish this end there must be a definite relation between the gas used and the space to be disinfected; and that the space shall be so closed that this relation may be maintained for a definite length of time.

Its powers of penetration cannot be relied upon, and when used in rooms, hospital wards, etc., all articles, such as mattresses, pillows, clothing in chests, closets, trunks, etc., had better be subsequently subjected to disinfection by streaming steam.

The methods thus far tested for the generation of this gas that have shown themselves to be *least* trustworthy are those in which methyl alcohol is slowly burned in lamps. As a rule, the lamps have been too small and their continuous combustion too uncertain; moreover, even with the best of them the actual amount of formaldehyde produced has been but a comparatively small proportion of the amount that is theoretically possible. It is not improbable that these defects may be overcome in some of the devices subsequently to be introduced.

The methods that have found *most* favor are those in which the nascent gas is liberated from its watery solution and from its solid polymerized products. In the former case this is accomplished through the employment of autoclaves in which the solution, either formalin or formochloral (a mixture of formalin, practically free of methyl alcohol, and calcium chloride) is placed, and is brought to a high temperature under pressure. When it is sufficiently heated, the gas is liberated by the opening of a valve and is conveyed through a tube into the apartment to be disinfected; or in other forms of apparatus a temperature sufficiently high to dissociate the gas is obtained by passing its watery solution through a highly-heated metal coil, which in turn is connected with a tube for the delivery of the gas into the apartment for disinfection.

By the latter process—*i. e.*, the decomposition of its solid form—tablets of compressed, polymerized formaldehyde are simply heated in a properly constructed vessel over a free flame. By the high temperature to which they are thus sub-

jected the polymerized body is decomposed into its constituent molecules, and formaldehyde is set free as such.

Since no two apartments present identically the same conditions, it is manifestly impossible to lay down fixed laws for the use of formaldehyde as a practical disinfectant for dwellings, and doubtless it is this circumstance that is in part, at least, answerable for the discrepancy in the results of its use by different investigators. It may be said, however, that for general practice the following procedures are necessary: Because of the diffusibility of the gas at ordinary dwelling-room temperature all cracks and crevices through which it could escape from the room are to be closed, either through the use of adhesive paper or by plugging with rags or raw cotton. If either the lamp, generating the gas from methyl alcohol, or the apparatus that liberates it from solid tablets of polymerized formaldehyde are to be used, they are placed in the center of the room and ignited; if the former, at least 1 quart of methyl alcohol is to be burned for every 1000 cu. ft. of room to be disinfected; if the latter, from 50 to 75 tablets are to be decomposed for the same cubic air-space. The room is to be kept closed for ten to twelve hours, after which it should be thoroughly aired. By either of these procedures it is necessary to leave a lighted lamp unattended in a closed room for a comparatively long time, so that it is advisable to take precautions against fire; such, for instance, as standing the apparatus upon a large sheet of tin or in a large tin pan.

If either of the forms of apparatus used to generate the gas from its watery solution be employed, this is set in operation in the hallway or in an adjoining room, and the gas is passed from the generator into the room by means of a tube passed through the key-hole, the room in this case, as in the other, having been made as nearly air-tight as possible. In this process a safe rule is to evaporate the gas from one pound of formalin or formochloral for every 1000 to 1200 cu. ft. of space to be disinfected, and to keep the room closed for five or six hours after the gas has been generated. At the end of this time the room should be thoroughly aired.

In our personal experience we have obtained the most satisfactory results through the use of formalin to which 10 per cent. of glycerin has been added, as recommended by Schlossmann; and through the employment of a generator[1] after the plan of that devised by Novy and Waite—viz., a simple copper retort into which the formalin-glycerin mixture is placed and from which the gas is disengaged by heat and conveyed through a tube into the room to be disinfected (Fig. 42). In these tests we found that 80 per cent. of all exposed infected objects in a room could be disinfected when 500 c.c. of the formalin-glycerin mixture per 1000 cu. ft. of air-space was completely evaporated and the room kept closed for three or four hours.

After disinfection the disagreeable and irritating odor of formaldehyde may be removed by sprinkling the room with ammonia water, or by placing in the room several open pans containing ammonia.

The gas is not poisonous, though very irritating. It has little or no destructive action upon objects in the room and, as stated, is highly to be recommended as a superficial disinfectant, though its penetrating action is uncertain.

In addition to its disinfecting properties formaldehyde is a marked deodorizer, combining to form odorless compounds with such bodies as sulphuretted hydrogen, ammonia, mercaptan, and other offensive products of decomposition. For the disinfection and deodorization of closets, vaults, safes, etc., in which such malodorous and, at times, infected objects, as bank-notes, public documents, and papers are stored, it has proved to be of very great service.

Carbolic acid is employed as a disinfectant, in the form of watery solutions of from 3 to 5 per cent. strength by weight.

It is unreliable for the disinfection of spores, but occupies a high place in the list of disinfectants to be used against the non-spore-forming infective bacteria. In 5 per cent. solution it is a useful disinfectant for sputum, vomited matters, and fecal evacuations; and in 2 per cent. solution may be safely

[1] The apparatus mentioned is made by Messrs. Chas. Lentz & Sons, Phila.; a similar apparatus is also made by Messrs. Parke, Davis, & Co.

employed as a wash for wooden surfaces, furniture, floors, etc.

In its crystalline form and in its stronger solutions it is possessed of *poisonous properties*, and *should always be so labelled*, to avoid accidents. It is also in these forms, especially the crystalline, an active escharotic, and should not therefore be handled with the fingers.

In order to obtain its germicidal action its solution must be thoroughly mixed with the matters to be disinfected, so that it comes in intimate contact with them.

It is valueless as an air-disinfectant, and neither spraying the room nor the placing about of open vessels containing carbolic acid has any appreciable effect beyond the generation of its odor throughout the premises.

A 1 per cent. solution of the pure acid, when allowed to act under the most favorable circumstances (*i. e.*, in laboratory experiments), is destructive to the pathogenic cocci, the bacillus of typhoid fever, the spirillum of Asiatic cholera, and numerous other non-spore-forming pathogenic bacteria. In practice, however, stronger solutions should be employed, rarely weaker than 2 per cent., for the reason that the conditions under which it is to act are always much less favorable than are those under which the laboratory tests are made.

A convenient method for using carbolic-acid solutions is to dissolve about six ounces of the pure carbolic acid in a gallon of hot water, which is approximately a 5 per cent. solution—that is, a saturated solution. From this dilutions may be made, and it is advisable not to use dilutions weaker than from 2 to 2½ per cent.

Carbol-sulphuric acid represents a mixture of equal parts of crude carbolic acid and concentrated sulphuric acid. The mixture is made by slowly adding to the carbolic acid, which is contained in a vessel that stands in water for the purpose of checking the development of heat, an equal volume of concentrated sulphuric acid.

From this mixture solutions of from 2 to 3 per cent. can be made in water. This is not an actual solution, but is rather an emulsion.

Sulphuric acid not only renders the insoluble crude carbolic acid more soluble, but increases its germicidal properties as well. The preparation is used only for the disinfection of sinks, cesspools, urinals, gutters, privy-vaults, etc. It should not be allowed to remain for any considerable length of time in contact with metal, brass fixtures, etc. Its disinfectant value is about equal to that of the pure acid, but the cost of the preparation is only one-third to one-half that of the pure acid.

Carbol-soap solution is prepared as follows: dissolve 3 parts of soft soap in 100 parts of warm water. When the solution is complete add, slowly stirring as it is added, 5 parts of the commercial (not the pure) carbolic acid. This forms a permanent solution having about the same disinfectant value as a solution of the pure acid, and is useful for the disinfection of bed- and body-clothing before they are sent to the laundry. The articles should be thoroughly immersed in it and allowed to remain for two or three hours. It may also be used for general scrubbing purposes. Since it has some bleaching properties, it is best to restrict its use to the disinfection of white goods.

The *cresols*—meta-, para-, and ortho-cresol—obtained by distillation from coal-tar and from crude carbolic acid, have been shown to possess high germicidal properties. Their activity is increased by the addition of an equal bulk of sulphuric acid. A 4 per cent. solution of these acid mixtures was found by Fränkel to destroy spores of *bacillus anthracis* as follows: Meta-cresol, in eight hours; para-cresol, in ten hours; and ortho-cresol, in twenty hours. For coarse disinfection Fränkel recommends a 5 per cent. solution of a mixture of equal parts of the raw cresols and conc. sulphuric acid. This is destructive to spores in five to six hours, while a 3 per cent. solution is germicidal for non-spore-forming bacteria, in a few minutes. It may be used for the same purposes as carbolic acid.

Tricresol is a refined mixture of the three cresols mentioned above, in about the following proportions: Meta-cresol, 40 per cent.; para-cresol, 25 per cent.; ortho-cresol,

33 per cent. It is soluble in water in from 2.2 to 2.5 per cent. It possesses about three times the germicidal value of carbolic acid, and is, therefore, particularly useful for disinfection in connection with surgical and obstetrical work, especially since its activity is but little diminished by the presence of albuminous matters.

Like carbolic acid, the cresols are poisonous.

Solutions of tricresol, in water, of from 0.5 to 1.0 per cent. strength, are germicidal for sporeless bacteria in a few minutes and in a few seconds respectively.

Creolin is a coal-tar product possessing relatively high disinfectant properties. It is a thick fluid resembling, in a way, crude carbolic acid. It is nearly insoluble in water, so that dilutions of it are really emulsions, and require, therefore, to be thoroughly agitated each time they are used. The germicidal activities are interfered with by the presence of albuminous matters in the mass to be disinfected. In practice it is used as a 2 to 5 per cent. emulsion in water, and should be thoroughly mixed with the matters to be disinfected. It is especially useful for the disinfection of urinals, drains, gutters, kennels, stables, etc.

Bichloride of Mercury.—Notwithstanding the conspicuous germicidal properties of this salt, there are objections to its use in general practice. It is an active poison ; it has a corroding action upon all metals with which it comes in contact ; its germicidal activities are very much diminished by the presence of albuminous matters in the mass to be disinfected, and its solutions are unstable unless protected from light and air.

Since it is an active poison whose solution is colorless, it is always wise to add to the solution some inert coloring matter—fuchsin, for instance—that may serve to distinguish it and thus aid in avoiding accidents.

It is employed for general disinfecting purposes in solutions of from 1 : 1000 to 1 : 5000 strength. In these proportions it is useful for the scrubbing of woodwork, floors, pavements, gutters, etc., and for wiping down walls that are not injured by it. It is also of service as a preparatory disinfectant for

infected clothing before they are sent to the laundry, though the stains of blood and feces *are rendered almost indelible* by long soaking in this solution. The clothing should be immersed in the solution for two hours.

If sublimate solutions are to be employed for the disinfection of feces, sputum, and other matters containing albumin, certain precautions must be taken—viz., the mass must be mixed in either an earthenware or wooden vessel, as corrosive sublimate both destroys and becomes itself destroyed when in contact with metal. To prevent its precipitation by albumin, and hence loss of germicidal powers, the solution should always contain a certain amount of sodium chloride.

A useful formula for this purpose is to add to a 1 : 2000 corrosive-sublimate solution common salt in the proportion of from 0.5 to 1 per cent.—in other words, to a gallon of the sublimate solution four teaspoonfuls of salt. The solution must be made in a glass or wooden vessel.

Silver nitrate is, according to all experiments, as active a germicide as corrosive sublimate, and has the advantage, according to Behring, over the mercury salt of being much more trustworthy for use with substances containing albumin.

In 1 : 1200 solution it destroys anthrax spores in seventy hours, while the organisms of cholera, typhoid fever, glanders, and diphtheria are killed in two hours by solutions of 1 : 2500.

Chloride of Lime.—There are few more useful disinfectants than a good preparation of chloride of lime, and by good preparation is meant one in which the proportion of available chlorine does not fall below 25 to 30 per cent.

A solution in water of such a preparation in the strength of 0.5 to 1 per cent. by weight has been shown to disinfect typhoid and cholera stools completely in ten minutes, while a 1 per cent. solution destroys *bacillus anthracis*, in laboratory experiments, in two hours. In order for it to manifest its germicidal properties it is necessary that the solution should be brought in intimate contact with the objects to be disinfected. The common practice of placing about open dishes containing small amounts of chloride of lime has little more

effect than to create a disagreeable odor. The preparation is cheap, is not poisonous, and is efficient; but it must be remembered that it easily undergoes decomposition, and should be made up fresh when it is needed for use, and should be made from freshly-prepared salts. Its efficiency depends upon the amount of chlorine contained in it in the form of hypochlorites.

The disagreeable odor of chloride may be eliminated by hanging about cloths soaked in strong soda solution after disinfection is complete.

Labarraque's solution, the official *liquor sodæ chlorinatæ*, depends for its disinfecting properties, like chloride of lime, upon the chlorine present as hypochlorite. It should contain at least 3 per cent. of available chlorine.

For use it is diluted with five times its bulk of water, which gives a solution of 0.5 per cent. of chlorine. It may be used for the same purposes as the chloride-of-lime solution. It is a more attractive preparation, but also more expensive, than the lime salt.

Milk of Lime.—This preparation is little more than fluid "whitewash." It is made by slaking 1 quart of finely divided, freshly burned lime in 1 quart of water, after which 3 quarts of water are added and the mass thoroughly stirred.

The active mixture consists of lime dissolved and suspended in water. It should always be freshly prepared and thoroughly stirred, before being applied to the affected mass.

It is principally used for the disinfection of feces, privies, gutters, etc., and when so employed should be mixed with the mass to be disinfected until the whole reacts, distinctly alkaline, as determined by the use of litmus paper. For the disinfection of cholera and typhoid stools a good rule is to mix thoroughly with them an equal volume of milk of lime and allow it to stand covered for one hour, after which it may be diluted with hot water and poured slowly into the water-closet, the flush of the closet being allowed to run at the same time. It should not be thrown into the water-closet without dilution, for the reason that the thick mass, especially the lime, may accumulate and obstruct the pipes.

Used as "whitewash," it is an important disinfectant for the walls of hospitals, barracks, cellars, and other apartments where contagious disease or infective or putrefactive matters may have been.

Soda Solutions.—Experiment has shown that a solution of common washing soda, especially when heated, possesses very marked germicidal activities. In addition to this it is one of the most useful cleansing agents. For scrubbing and general cleaning purposes the solution recommended is 1 part of soda in 25 parts of boiling water—*i. e.*, 4 per cent. by weight. Applied *hot*, this not only removes dirt, but disinfects as well.

For use as a disinfectant for bed- and body-clothes, instruments, eating-utensils, etc., it is employed in a 2 per cent. solution at boiling temperature. An ordinary wash-boiler is a convenient apparatus in which to carry out the process.

Caustic Soda: Caustic Potassa.—Solutions of either of these salts in the strength of 0.5 to 1 per cent. are destructive in two hours to such pathogenic bacteria as *bac. diphtheriæ*, *bac. typhi abdominalis*, and the glanders bacillus. Spore-bearing materials require stronger solutions, the spores of anthrax being killed by a 4 per cent. solution in forty-five minutes.

Caustic ammonia has no effect upon spores, but is germicidal in two hours for practically all non-spore-bearing pathogenic bacteria in solutions of from 0.3 to 0.6 per cent. of the official solution in water.

Acids.—Many infective micro-organisms are extremely sensitive to unusual variations in the reaction of the medium in which they are located. The majority of acids, especially the mineral acids, serve, therefore, a useful purpose when used as disinfectants, though their employment is limited because of their effect upon metal objects, with which they may come in contact.

Hydrochloric acid in the strength of 5 : 1000 solution readily destroys non-spore-forming pathogenic bacteria in two hours, though in even four times this strength—*i. e.*, 2 per cent.—it requires as long as ten days to kill the spores of anthrax.

Sulphuric acid, in from 2 to 15 per cent. solution, requires from fifty-three hours to eight days to destroy spores; while in 5 : 1000 it is fatal to practically all non-spore-forming bacteria having pathogenic properties, in two hours.

Permanganate of potash has little or no disinfecting powers when used in its ordinary watery solution. It is employed in this condition more as a deodorizer. The strength of the solution is about 4 ounces of the salt to the gallon of water. When used in its strong alkaline or acid solution a low degree of disinfective activity may be exhibited, but it is never to be relied upon.

Sulphate of iron is used as a disinfectant and deodorizer for privy-vaults, cesspools, fecal matters, etc.

For this purpose 4 pounds of the salt dissolved in a gallon and a half of water are to be used for every cubic yard of the vault to be treated.

As a germicide it is not so trustworthy as are the other preparations recommended for this purpose, and though frequently used its benefits are more as an antiseptic and deodorizer than as an actual germicide.

Garden Earth.—Well-dried and sifted garden loam has marked deodorizing powers over fecal matters.

If mixed with a very small quantity of pulverized lime, so that the latter is present in from 4 to 6 per cent. by weight, it is said to have a certain degree of disinfective action, and this mixture is recommended by some authors, but unfortunately the lime, by its germicidal action upon the bacteria in the earth, may defeat the very object for which the earth is used—*i. e.*, the destruction, *by nitrification*, of the organic constituents of the feces, and by this the prevention of putrefactive odors.

Garden loam cannot be regarded as a trustworthy disinfectant, and if the evacuations require disinfection, some other safer process should be employed. It is only a deodorizer and disintegrator.

For deodorization enough *dried* earth must be used to cover the feces completely. Moisture interferes with the

process of deodorization in direct proportion to the amount present.

Chalk, gravel, or sand is not suitable for this purpose.

The figures given above for the strengths of solutions of the various disinfectants recommended are those obtained by laboratory tests under the most favorable conditions.

They teach that in the practical use of disinfectants it does not answer to sprinkle about the premises or over the mass to be disinfected a little, more or less, of the disinfectant to be used, but that a definite quantity must be employed for a minimum length of time before the best results can be expected. Thus, for instance, it has been said above that a 3 per cent. solution of carbolic acid, a 0.1 per cent. solution of corrosive sublimate, and a 1 per cent. solution of chloride of lime are useful disinfectants, but this does not mean that the addition of such substances at random to the infected matters always results in successful disinfection. It means rather that the agents must be in intimate contact with the materials to be disinfected, in proportions not less than those expressed by the figures given. Thus, if it were desirable to disinfect a mass of feces of about a liter capacity with chloride of lime in the strength of 1 per cent. solution it would be necessary to mix thoroughly with it either 10 grams of the salt in substance, or, what would be better, a liter of a watery solution of the salt in the strength of 2 per cent., so that in the resulting mixture chloride of lime would be present in not less than half this amount—*i. e.*, the desired 1 per cent. So it is with the other disinfectants mentioned.

Special Chemical Disinfection.—Privy Vaults, Evacuations, etc.—In the first place, privy vaults, or any other contrivance for the accumulation of excrementitious matters, should not be tolerated in thickly-populated communities. Unfortunately, however, they are occasionally encountered and therefore require care. By the frequent removal of the contents of cesspools and the continuous employment of disinfecting materials we not only prevent the offensive odors consequent upon putrefaction, but check the development or

destroy outright the germs of disease that may gain access to them. It is often recommended to use deodorants in this connection, under ordinary circumstances, and to employ disinfectants only when the privy is known to contain infective matters, such as cholera or typhoid stools. Since it is just as simple and as cheap and always safer to employ disinfectants as a routine practice, we prefer to recommend this procedure. By their frequent use the development of all germ life is checked, and therefore putrefaction with its bad odors is also prevented.

The cheapest and probably the most practical disinfectant for the contents of privy vaults is milk of lime, made after directions given above. This should be mixed with the mass to be disinfected in the proportion of about 2 per cent. of the contents of the vault, or it should be added and be thoroughly mixed until the entire mass reacts distinctly alkaline to litmus paper. Another rule is to add to the cesspool about 2 liters (quarts) of milk of lime daily for each individual using the privy. By beginning with an empty and clean privy vault and adding the lime mixture daily, not only is the odor prevented, but the mass is continuously disinfected.

Sulphate of iron is highly recommended for the suppression of offensive odors from such receptacles.

The liberal sprinkling of chloride of lime in powder over the mass in a cesspool, not only serves to disinfect but to check putrefactive odors as well.

It is always advisable, however, where cesspools must be used, to disinfect thoroughly all infected matters, such as typhoid, dysenteric, and cholera stools, before they are emptied into the vault, as disinfection is much more certainly and easily accomplished with such small volumes of matter than it would be after the entire mass in the vault had become infected.

Water-closets, Urinals, and Sinks.—The continuous treatment of water-closets, urinals, and sinks is called for more to suppress bad odors than to destroy infective matters. As a routine practice cleanliness, in this respect, is above all

other modes of procedure, and in private houses is usually all that is required.

In public places, however, it is to be recommended that the ordinary modes of mechanical cleaning, often only imperfectly performed, should be supplemented by steps to prevent putrefaction and consequent bad odors. For this purpose the 3 per cent. carbolic-acid, or the 1 per cent. chloride-of-lime solution will be found useful. The closet-pans and the urinals should be thoroughly brushed once a day with the disinfectant.

The odor that is almost constant in and about public urinals is, as a rule, due to neglect of the ordinary laws of cleanliness. It arises from the decomposition of urine that has not been passed into the proper receptacle. It may be obviated by constant scrubbing, by the free sprinkling of the premises with either of the solutions named, or may be masked by placing lumps of camphor or of carbolized soap in the urinals.

Where infective matters have gained access to water-closets or sinks, these receptacles should be thoroughly scrubbed with 5 per cent. carbolic-acid, or 2 per cent. chloride-of-lime solution. Sufficient of the solution should be passed into them to fill the trap completely, and there should always be a residue of from a pint to a quart of the solution in the body of the fixture. This should be repeated after each time the closet is used for infected discharges. As stated above, however, infected evacuations should *always* be disinfected before they are thrown into the closets.

Stables and Cellars.—When suspected of being infected the walls, floors, ceilings, and all objects upon which suspicion rests should be thoroughly saturated, without otherwise disturbing them, with either the 5 per cent. carbol-sulphuric acid solution, or 5 per cent. creolin solution, or 2 per cent. chloride-of-lime solution, and kept wet with it over night. The premises should then be thoroughly cleaned with a boiling 4 per cent. solution of common washing soda.

In the case of cellars and the less elaborate stables, the walls and ceilings should be whitewashed.

The harness worn by diseased animals, especially bits, should be first disinfected with one of the solutions named above, then thoroughly washed with hot soda solution, and finally rinsed with warm water and dried.

The *disinfection should always precede the cleansing*, otherwise infective matters in a living state may be disseminated from the infected focus during the ordinary steps of the cleansing process.

Disinfection of Wells and Cisterns.—It is not necessary to emphasize the fact that where possible all suspicious drinking waters should be abandoned, and that water for domestic uses should be beyond suspicion of pollution; but circumstances may arise through which a well, the only readily available source of supply for an isolated family, settlement, or company of soldiers, may become temporarily infected and seriously inconvenience the users of the water, unless some safe remedy is at hand. To meet the requirements of such cases efforts have been made to determine in how far it is possible to disinfect wells, with the result of demonstrating that this is a practicable procedure, providing the pollution has been but to a slight extent and is not continuous. Of course, a well fed by polluted ground water, or a well into which infective matters are continuously and unavoidably passing from the surface, cannot be rendered safe by any process of disinfection, and should be abandoned.

The methods that are recommended for the disinfection of wells that have been only temporarily polluted, as by the accidental deposition into them of infective matters from above, or by the washing into them of such matters as a result of excessive rains, are as follows:

If the water be raised to the surface by a pump, remove the latter and pour down the pipe a mixture of equal parts of raw carbolic acid and sulphuric acid until it is present in the proportion of about 5 per cent. of the contents of the well. The water should be thoroughly stirred so as to complete the mixing of the acids with it, and the walls of the well should be scrubbed with brooms dipped in the water. The inside of the delivering pipe should be thoroughly cleaned by

mechanically scrubbing it with a long-handled brush wet with the acid solution. After standing for twenty-four hours the contents should be pumped out, the slime from the bottom thoroughly removed, the well allowed to refill; this water is again pumped out, and this must be repeated until all traces of the acid have disappeared. Another plan consists in the use of lime. Here the delivery pipe, if a pump is used, is to be scrubbed on its inside with strong carbolic-acid solution; there is then to be thrown into the well about 40 to 50 pounds of freshly burned lime; after the lime dissolves, the walls of the well are to be thoroughly scrubbed with its solution. The contents are then pumped out, or otherwise removed; the slime from the bottom is baled out completely, and lime in the same proportion is again added and allowed to slake and dissolve as the well refills. The whole is, after twenty-four hours, to be thoroughly stirred and again removed. The well is again allowed to refill and is re-emptied, and this is continued until the pumped water is practically free from lime.

With tube wells only the inside of the tube needs attention. This should be thoroughly brushed with the carbol-sulphuric-acid mixture, and water pumped through it until the acid (phenol) reaction disappears.

Cisterns should be treated as wells.

These procedures are not ideal from a sanitary standpoint, but circumstances may arise when they would be far better than no precautions at all.

For drinking purposes alone all water that is of necessity derived from suspicious sources should be boiled before being used, and no process of chemical disinfection can in any way compare with this method from the standpoint of safety and practical utility.

Disinfection of the Hands.—Of the numerous methods recommended only two will be given as thoroughly trustworthy—viz., that of Fürbringer and that of Welch, as developed at the Johns Hopkins Hospital.

Fürbringer's method:

1. Remove all dirt from under and around the nails.

2. Brush nails and skin of hands thoroughly with soap and hot water.

3. Immerse in alcohol, 95 per cent. for not less than a minute, and before this evaporates.

4. Plunge the hands in 1 : 500 corrosive-sublimate or 3 per cent. carbolic-acid solution, and thoroughly wash them for at least a minute, after which the hands may be rinsed in warm water and dried.

Welch's method:

1. The hands and nails are to be thoroughly cleansed with hot water and soap. The water is to be as hot as can be borne, and the brush used is to have been sterilized by steam. This preliminary brushing to occupy from three to five minutes.

2. The hands are then rinsed in clean warm water.

3. They are then immersed for one or two minutes in a warm, saturated solution of permanganate of potash. While in this solution they are rubbed thoroughly with a sterilized swab of absorbent cotton.

4. They are then placed in a warm, saturated solution of oxalic acid and kept there until completely decolorized.

5. They are then thoroughly washed in clear sterilized water or salt solution.

6. Finally, they are immersed for two minutes in 1 : 500 corrosive-sublimate solution, rinsed in water, and dried.

Disinfection through Physical Processes.—Under this head are embraced methods for the destruction of infective agents by the use of such physical influences as are antagonistic to their vitality, as for example, heat, cold, electricity, light, and pressure.

Disinfection by Heat.—Heat in one form or another is the most trustworthy germicide that we possess. It is employed according to circumstances as ordinary fire, free flames, and as dry heat, the articles to be disinfected being protected in a properly-constructed oven; as boiling water; as streaming or live steam; and as steam under pressure.

Fire.—The free flames are resorted to only when it is desirable to consume valueless articles completely which would hardly pay for the trouble of disinfecting by the usual processes, such, for example, as old straw mattresses, worn-out clothing, useless furniture or bed-clothing, etc.

Dry Heat.—The process of disinfection by dry heat in ovens constructed for the purpose was formerly much more in vogue than it is at present. It has been practically abandoned for the reasons that dry heat has but little penetrating power as compared with steam; that it requires a longer time for disinfection than is necessary for steam; and that the high temperature and prolonged exposure are together detrimental to many articles that are disinfected by this method.

Complete disinfection by dry heat cannot always be anticipated, even when a temperature of 130° to 140° C. has been maintained for as long as three hours, conditions that are manifestly destructive to many articles that might be subjected to the process.

It is only to be recommended when no other means are at hand.

Boiling.—Boiling water destroys all pathogenic bacteria and their spores in five minutes. Its disinfecting action is further increased by the addition of 1 to 2 per cent. of soda. This is an especially handy method for domestic disinfection of clothing, eating-utensils, etc. A wash-boiler is simply filled with water or soda solution, which is brought to the boiling point, and the articles are immersed in it and boiled for five or ten minutes. For the disinfection of surgical instruments the boiling soda solution has found very general favor.

Streaming or Live Steam.—For disinfection by this method special forms of apparatus are manufactured. They are sold under the name of "steam sterilizers" and "steam disinfectors." The simplest construction for domestic purposes is the ordinary potato steamer that is used in the kitchen, the articles to be disinfected being placed in the upper compartment, the water in the lower, the cover placed in position

and the apparatus placed over the fire and the water kept boiling from ten to fifteen minutes. Several refinements of this apparatus are now to be had, the one that has found most favor being that sold as "Arnold's Steam Sterilizer." For more extensive use more elaborate and varying designs of these steamers are employed. They are usually of such size and strength as to accommodate a mattress, or a bundle

FIG. 43.—Portable steam disinfector, equipped with chamber of sufficient size to accommodate bed-clothing, mattresses, etc., and a boiler for generating steam.

of clothing, etc. (in Fig. 43 is depicted a very serviceable portable form of steam disinfector). The principle involved is the same in all of them, the point aimed at being to keep the articles fully exposed to the penetrating action of live steam for the time necessary to disinfect them.

For complete disinfection with streaming steam twenty-five minutes is necessary with loosely placed articles, while an hour is not too long when the articles are closely packed in the apparatus. In both instances the time of disinfection is to be reckoned from the time at which steam begins to stream freely from the apparatus.

Steam under Pressure.—Disinfection by this process is accomplished by subjecting the infected articles to steam that is confined in a closed chamber. As it is under additional

pressure because of its confinement, it is at a correspondingly higher temperature. By this method the disinfection of larger, bulkier objects, such as bales of rags, packages of merchandise, bundles of clothing, etc., is more certainly and quickly accomplished, because of the higher temperature and excess of pressure under which the steam is kept. For disinfection, on the large scale, as at hospitals, lazarettos, quarantine stations, etc., this form of apparatus has almost taken the place of that in which streaming or live steam is used

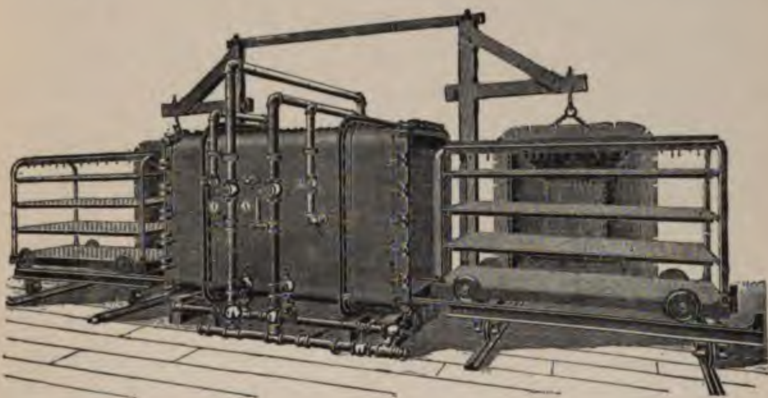


FIG. 44.—The "Kny-Sprague" disinfecting chamber, equipped with cars for loading the chamber with articles to be disinfected.

(Fig. 44). In the simplest form of this apparatus the articles are placed in the chamber, the door closed and clamped, and the steam turned on until the required temperature and pressure are reached; this is then maintained for the time necessary to disinfection. To meet important requirements certain modifications have been made in the construction of these chambers, the most important being those that aim to displace all air from the chamber and from the meshes and pores of the articles to be disinfected, by beginning the process with the exhaustion of the air from the chamber, then turning in the steam, again exhausting and again turning in the steam, and continuing this until all the air has been removed and only steam is in contact with the object. This is manifestly

advantageous, otherwise portions of the chamber would contain heated air and, as we saw above (see Dry Heat), hot air has not the germicidal powers of steam. Another modification aims to assist in the drying of the objects after disinfection, but this does not seem to be necessary, as they dry very quickly if freely opened.

The pressure commonly employed in this form of disinfection varies between $\frac{1}{20}$ and 1 atmosphere, and often more, and for ordinary articles thirty minutes under from $\frac{1}{2}$ to 1 atmosphere suffice for disinfection in a properly constructed apparatus. For very dense objects, such as closely pressed bales of rags, dry goods, etc., an hour to an hour and a quarter is necessary; but by using higher pressure this time may be shortened. This form of disinfector is a massive, permanent fixture, usually constructed of iron and encased in a non-conducting medium. The steam-supply is obtained from a boiler either especially connected with the disinfector or from one close by that is used for other purposes and which may, as occasion requires, be called upon for the necessary amount of steam for disinfection (Fig. 44).

A point of great importance in connection with the management of disinfecting apparatus, especially the large chambers, is the precaution that should be taken to prevent the reinfection of the disinfected articles by those who manipulate the disinfector.

With disinfection on the small scale—*i. e.*, domestic disinfection—the person who has handled the infected objects should thoroughly disinfect his hands and arms and don a sterilized apron while the apparatus is in operation, so that in removing the articles after the process is complete there will be no danger of his reinfecting them.

In the case of the large disinfecting plants it is customary to have them erected in a building especially designed for their accommodation. This should be constructed with a central partition at right angles to the long axis of the room. The disinfector should be built in this partition so that its ends project into the apartments on either side of the partition. Running along the long axis of the building and

through the disinfectors are tracks on which run light cars or trucks, on which the articles to be treated are hung or packed. The car, constructed of iron netting, is of such size that it fits easily into the disinfecting chamber. There are two crews of attendants: the one to handle *only* the *infected* articles—*i. e.*, to load them upon the carriage, pass them into the chamber and clamp the door; the other, to handle *only* the *disinfected* articles—*i. e.*, to remove them from the apparatus after disinfection, and properly distribute them.

While on duty these crews do not come in contact with one another. It is customary also to distinguish the two sets of operators by uniforms of different colors, and under no circumstances are the men or objects from the *infected* side of the building allowed to mingle with those on the *disinfected* side. The only channel of communication is the steam-chamber in the wall; and it is advisable to have the doors of the apparatus so arranged that both are not open at the same time and can only be simultaneously opened by special means. By simple mechanical contrivances it is easily possible to accomplish this and thus shut off the only means of direct communication between the infected and disinfected sides of the apparatus. The goods to be disinfected should be brought to the station, and those that have been disinfected are taken from the station in closed wagons that are distinguished from each other by colors corresponding to the uniforms of the crews of operators.

The uniforms of the attendants should be disinfected at the end of each day, and the walls, floors, etc., of the room for reception of infected articles should be cleansed each day with a disinfecting solution. The room for reception of disinfected articles should be provided with closets, etc., and all should be kept scrupulously clean. For their own protection, as well as that of those about them, the operators who manipulate the infected articles should be provided with conveniences for bathing and personal disinfection.

In addition to heat the physical influences that are detrimental and destructive to the vitality of infective bacteria are desiccation, sunlight, electricity, and vigorous agitation; though

these are not, as a rule, deliberately used for the disinfection of dangerous materials.

Desiccation.—All living micro-organisms are sooner or later attenuated in their pathogenic activities, and finally killed, by drying. With the non-spore-forming species, and particularly certain of those possessed of disease-producing powers, this effect is occasionally conspicuously manifest. With the spores of spore-forming bacteria, on the contrary, drying requires a much longer time to attenuate and still longer to kill them, the spores of certain forms retaining their vitality in some cases for many years when dried (anthrax). Fortunately, however, only a small proportion of the known disease-producing bacteria form spores, so that desiccation, even such as occurs with the ordinary environment of pathogenic bacteria when outside the body, is of importance in arresting their development, and ultimately in destroying their vitality. Thus, for instance, in laboratory experiments it has been demonstrated that the spirillum of Asiatic cholera when dried dies in from three hours to two days, according to the degree of desiccation; the bacilli of typhoid fever, of tuberculosis, and of diphtheria resist drying for a longer time, but gradually lose their vitality, and after from a few weeks to months die.

The influence of drying in checking the multiplication of bacteria—for none of them develop in the dry state—and of gradually destroying them, is of manifest importance in the spontaneous elimination of infective diseases.

Sunlight.—A large proportion of the sporeless pathogenic bacteria are killed by the direct rays of the sun. In laboratory experiments this effect is very striking, many species being destroyed in the presence of sunlight and air in so short a time as from one to two hours. Diffuse daylight is also detrimental to pathogenic micro-organisms, though its action is less energetic than is that of direct sunlight. These experiments have shown that the bacillus of typhoid fever is destroyed in from one and a half to two hours by direct sunlight, and in five hours (Buchner) by diffuse daylight. *Bacillus diphtheriæ* is destroyed by from one-half to one hour's exposure to the

direct rays of the sun; and Koch states that the tubercle bacillus is killed by sunlight in from a few minutes to several hours, according to the thickness of the mass exposed, and by diffuse daylight in from five to seven days. Similarly, many other pathogenic and non-pathogenic species, such as the pneumococcus, the pyogenic cocci, the anthrax bacillus, the cholera spirillum, and others are seen to succumb to this influence.

In the light of these laboratory demonstrations Esmarch has endeavored to determine in how far the direct rays of the sun may be employed for practical disinfection. For the tests he purposely infected such articles as furniture-covers, pillows and pillow-cases, furs, etc., and exposed them to the direct rays of the sun for varying lengths of time and under various conditions. As the result of these experiments he does not regard direct sunlight as worthy of confidence for the complete disinfection of such articles as he employed in the test. Its disinfecting activity was observed only upon *surfaces* that were freely exposed to it, and even here there were irregularities in the results. The time required for its best results was, moreover, so long as to make the method impracticable for routine purposes.

Nevertheless, there is every reason to believe that the continuous daily action of the sun's rays, together with desiccation, is an important factor in arresting the growth and activities of pathogenic bacteria when they are expelled from the animal body.

By laboratory experiments it has been shown that the germicidal properties of the sun's rays were most conspicuously present at the blue end of the spectrum, while the red end had little or no detrimental influence upon bacterial life.

Electricity.—The germicidal value of the electrical current is made evident in several ways—viz., through electrolytic decomposition of certain chemical compounds with which the bacteria may be associated, by which detrimental substances are set free; by the local elevation of temperature at the positive pole; and by the direct action of the electric current upon the bacteria themselves.

The results depend upon the strength of current and time of its application. It has been successfully employed in the purification of sewage and of polluted waters.

Mechanical Agitation.—The results obtained by a number of investigators have demonstrated that the life-processes of of several species of bacteria are markedly interfered with by excessive and long-continued shaking.

In some instances the bacteria exposed to continuous vibration were killed. The ordinary motion, such as bacteria experience in a current of quietly-flowing water, has apparently no such effect. Melzer demonstrated that *bac. megatherium* when exposed for four days to continuous vibration was killed, and microscopic examination showed them to be actually disintegrated. Hanson has found that for a particular water-bacillus slight motion was favorable, whereas excessive shaking was fatal.

ADDITIONAL PRECAUTIONS OF IMPORTANCE IN THE MANAGEMENT OF COMMUNICABLE DISEASES.

ISOLATION, THE SICK-ROOM, CLOTHING, EXCRETA, UTENSILS, ATTENDANTS, ETC.

Isolation.—In the modern sense the term "isolation," as applied to contagious diseases, comprehends not only the separation of the infected individual from those that are not infected, by placing him in a separate room or building, but the complete obstruction of all the manifold channels through which he may come in indirect communication with those who surround him. It would be manifestly absurd to place a patient in an "isolation ward" of a hospital or in a special room of a private dwelling and keep him there, unless care were taken that all articles with which he comes in immediate contact, and which may carry the infection, were also prevented from being generally used throughout the building.

Formerly, when the air was regarded as the principal disseminator of infective matters, elaborate preparations were made to cut off all aerial communication between the infected and the well, and isolation pavilions, wards, etc., were so constructed as never to communicate directly with other buildings in which non-contagious diseases were located; this was often the only, or at least the most conspicuous, step that was taken toward the isolation of the patient. While it is always proper to confine infectious and contagious patients in separate rooms in private houses and in special wards or pavilions in hospital cases, for the reason that their management is thereby very much simplified, it is important that we should fully understand this to be only a relatively small part of the elaborate precautions now recognized as constituting a complete and trustworthy system of isolation. Modern investigation has shown us that the foundation-work of a successful system of isolation comprises: (1) Knowledge of the mode and channels through which

infective matters are expelled from the body during the course of special groups of infectious and contagious diseases; (2) the careful employment of that knowledge in the application of approved means to the destruction of such matters as soon as they are expelled.

Thus, for instance, during the desquamative stage of the acute exanthemata—the period at which the danger from contagion is believed to be greatest—it is always advisable to prevent the dissemination of the morbific agents from the skin in the form of epidermal dust, by anointing the entire body with harmless antiseptic or disinfecting ointments. These cause the epidermal scales, presumably the carriers of the infection, to adhere to the patient, to whom they can do no harm, and from whom they may be washed with disinfecting solutions; but it would be manifestly absurd to subject to this treatment a cholera or typhoid patient, from whom the infective particles escape only from the bowels, kidneys, or with vomited matters.

Isolation means more than simply confining the patient to a separate room or building. It comprises in addition to this the employment of a separate attendant who comes in contact with only the patient or patients for whom he or she is employed to care; the disinfection of all infective matters as soon as they are passed from the patient and before they leave the sick-room; the disinfection of all bed- and body-clothing as soon as they are removed from the patient and before they leave his apartment; the provision of separate eating-utensils, handkerchiefs, towels, napkins, clinical thermometers, tongue-depressor, and other instrumental accessories; the frequent cleansing with disinfecting solutions of the sick-room and its furniture; the frequent general bathing of the nurse; and especially the careful disinfection of the hands after each manipulation of the patient. These steps will now be treated of in more or less detail.

The Sick-room.—The room should be light, of a comfortable temperature, and easily aired. Draughts should be avoided.

The furniture should be of the simplest kind, and neither

carpet nor hangings should be permitted unless, in the case of the latter, they be of cotton material that may readily be disinfected.

The room should be provided with a small gas stove and a wash-boiler of about 4 gallons capacity, or with a steam sterilizer, and all small infected articles, such as napkins, towels, handkerchiefs, etc., should be immersed in boiling water or soda solution, or steamed, when they become soiled and before being laundered.

The patient should be provided with his own eating-utensils, which are to be boiled in soda solution after he has used them. The refuse of his meals should be thrown into a covered receptacle containing milk of lime, or 1 per cent. chloride-of-lime solution, which should be renewed each day.

The furniture, the floor, and all horizontal surfaces, such as sills, mantlepieces, etc., should be frequently—at least once in two days—wiped with cloths moistened with a 3 per cent. solution of carbolic acid or a 1 per cent. chloride-of-lime solution.

The knobs of the doors should be similarly cleansed every day.

These patients should be provided with separate clinical thermometer, tongue-depressor, and whatever other instruments may be frequently required in their treatment. When not in use these articles should be kept in some one or another of the disinfectant solutions after having been cleansed in such solutions. They should be rinsed off in warm water before being used again.

When soiled by evacuations, secretions, or excretions, the body- and bed-clothing of the patient should be removed with as little agitation and commotion as possible, and at once immersed in a solution of

Carbolic acid,	3 parts;
Common soft soap,	2 "
Cold water,	100 "

contained in a covered vessel that is *brought to the bedside.* This prevents the dissemination of the morbific agents that

might occur if the infected clothing were carried loosely through the house or through the wards of the hospital. As soon as the objects are thoroughly saturated with the solution, the cover is replaced, and they are allowed to soak for two hours, when they may be rinsed out in clean water and subjected to the ordinary processes of the laundry, beginning preferably with boiling.

The reason for the immersion in the cold carbolic-soap solution is that this not only destroys all non-spore-bearing bacteria, but in the cold state dissolves out all blood and fecal stains which would be rendered indelible if the soiled articles were exposed at once to steam or boiling water.

Chloride of lime in 0.5 per cent. cold-water solution may be substituted for the above mixture, but as it has some bleaching effect had better be used only on white clothing. In the writer's experiments corrosive sublimate in 1 : 1000 solution has almost as great an influence in rendering blood and fecal stains indelible as does hot water at from 176° F. to the boiling point.[1]

Clothing.—The outer clothing of the attendants should always be protected by a cotton slip or coat that reaches from the neck to the floor. This coat or slip should always be worn when the attendant is on duty. At the end of the day it should be immersed in either of the solutions named above, after which it may be boiled or steamed and laundered. All other infected clothing should be packed in tightly-closing canvas bags and conveyed to the regular disinfecting station to be disinfected by steam.

Where such stations are not accessible, one may have recourse to the vapors of formaldehyde. The clothing should be hung loosely in a closet; a lamp for decomposing paraformaldehyde tablets should be procured, and tablets should be decomposed in the proportion of 75 per 1000 cu. ft. of space in the closet. The door must be closed during the process and should be kept closed for twenty-four hours afterward. This is not as certain as steam, and is slightly

[1] See *Trans. Internat. Congress of Charities, Correction, and Philanthropy*, Chicago, June 12 to 18, 1893.

dangerous because of the fire, but is to be recommended for domestic use when steam is not available. Infected articles may also be sprayed with a 4 per cent. formalin solution, though this is less trustworthy than where the nascent gas is used.

The attendant should also be provided with loosely-fitting carpet overshoes that should be repeatedly disinfected by steam.

Whenever the attendant has occasion to leave the ward or room, both the slip and overshoes should be left in the room at a point close to the door of exit, so that they are in easy reach when he returns.

The attendant should bathe as frequently as once a day, and his hands, face, beard and hair should be frequently rinsed in a 1 : 5000 solution of bichloride of mercury, or a 1 per cent. solution of carbolic, or a 1 per cent. solution of chloride of lime.

A solution that is suitable for sponging the entire body, both of patient and attendant, is one consisting of 1 part Labarraque's solution to 19 of water.

Disinfection of Stools and Sputum.—The stools of all patients suffering from infective intestinal disorders, such as typhoid fever, cholera, dysentery, intestinal tuberculosis, etc., should be disinfected as soon as they are passed; and this should constitute a part of the routine duty of the nurse in attendance. Since it is a simple process, there is no excuse for its not being regularly and faithfully carried out. It is the most important step in preventing the spread of these maladies, for they are disseminated wholly and alone through the living infective matters that are passed from the bowels and kidneys of individuals suffering from them.

If each evacuation, including the urine, from every case of typhoid fever, for instance, were disinfected as soon as passed from the patient, it is safe to say that this disease would soon disappear in large measure from among us.

Methods.—Mix with each evacuation double its volume of freshly-prepared milk of lime, or double its volume of 1 per cent. chloride-of-lime solution, or double its volume of 5 per

cent. carbolic-acid solution; or pour upon the evacuation three times its volume of *boiling* water or boiling 2 per cent. soda solution. In either case cover the vessel and allow it to stand in a safe place for from one to two hours before it is emptied into the closet.

What is said in regard to intestinal evacuations applies equally well to urine, vomited matters, pus, etc.

Sputum.—Sputum from tuberculosis, influenza, and pneumonia patients should be received in covered vessels containing either a 5 per cent. carbolic-acid solution, 2 per cent. tricresol solution, or a 1 per cent. chloride-of-lime solution. Or they may be spat into covered receptacles containing moist sawdust which, with their contents, are afterward disinfected (at the end of each day) in a steam sterilizer and the contents finally burned. Or it may be received in cheap, pasteboard receptacles that with their contents may be burned at the end of each day.

Room Disinfection.—There is as yet no single procedure by which every article in an ordinarily furnished infected room may be simultaneously and certainly disinfected.

It is always advisable therefore, where circumstances permit, to have but little unnecessary furniture, hangings, carpets, etc., in rooms occupied by the sick. For rendering rooms that have been occupied by persons suffering from contagious diseases free from danger, the most trustworthy plan consists in a combination of the best features of several methods that have been from time to time proposed.

The steps to be taken are briefly as follows: After the room has been vacated by the patient, all conspicuous cracks and crevices should be sealed, the door should be closed and locked, and the room kept closed for at least twenty-four hours. At the end of this time formaldehyde gas should be either generated in the room by the decomposition by heat of from 50 to 75 tablets of polymerized formaldehyde to each 1000 cu. ft. of air-space, or formaldehyde gas generated from its watery solution by an approved apparatus may be passed into the room from without. The amount of gas employed should be that given off from at least 1 pound of formalin or

formochloral for each 1000 to 1200 cu. ft. of air-space (see Formaldehyde).

After this the room should be kept closed for at least six hours. This accomplishes the necessary disinfection of all surfaces.

The room may then be entered and all bed-clothing, pillows, mattresses, other clothing in closets, chests, trunks, etc., should be put into canvas bags, brought for the purpose by the operators, and sent at once to a disinfecting station, where they are subjected to the action of steam. This completes the disinfection of those articles that were only superficially acted upon by the formaldehyde gas.

In the meantime the ceiling and walls are to be wiped down with cloths wrung out in 3 per cent. carbolic-acid, 1 : 2000 corrosive-sublimate, or 0.5 per cent. chloride-of-lime solution; and finally, all furniture and all horizontal surfaces, such as window-sills, cornices, etc., are to be similarly wiped off, after which the floor is to be scrubbed with hot soda solution of about 4 per cent. strength.

In the case of hangings, valuable curtains, tapestries, carpets, etc., that might be injured by steam disinfection, it is best to remove them after the action of the formaldehyde and have them thoroughly beaten or shaken on some distant open lot, after which they should be freely exposed to direct sunlight.

The object of each of these steps is:

The keeping of the room closed for a day after its vacation permits all dust to settle.

The generation of formaldehyde gas in the room disinfects the dust and all exposed surfaces, so that there is danger neither to the operators themselves nor of their conveying infective matters.

The wiping of walls, furniture, and surfaces, and the scrubbing of the floors with disinfecting solutions insures the destruction of infective matters that may have escaped the action of the formaldehyde gas.

The steaming of pillows, mattresses, bed-clothing, etc., insures the destruction of infective matters that may have soaked

into their deeper layers and escaped the action of the formaldehyde gas.

In some places sulphur dioxide gas is employed in place of formaldehyde and is often the only step taken for disinfection, but it is doubtful if the results are ever as satisfactory or as complete as when formaldehyde is properly used.

Again, the walls and surfaces are sometimes rubbed over with gluten bread, to which all dust and infective particles adhere, after which the bread is burned. This has no advantage over the cloths rung out in reliable disinfectant solutions.

When a room has been disinfected and cleaned by the process outlined above, it should be thoroughly aired for a few days before it is occupied.

On closing the room preparatory to its disinfection, the nurse or attendant whose duties it has been to seal up all cracks and crevices, before leaving should doff her over-slip and overshoes and leave them in the room to be disinfected with the other articles.

(See personal experience in room disinfection with formaldehyde under " Formaldehyde.")

Care of the Body after Death.—It is ordinarily advisable that the cadavers of patients who have died of the *most dangerous* communicable diseases be at once enveloped in a sheet saturated with either 5 per cent. carbolic-acid, 4 per cent. chloride-of-lime, or 1 : 1000 solution of corrosive sublimate, and placed at once in the coffin in which each is to be buried.

These cadavers should be buried as soon as decency permits. The law should, and usually does, forbid public funerals in these cases.

With the less dangerous infectious diseases, however, such stringent measures are not observed. The body after death may be washed in either of the strong disinfecting solutions mentioned, though because of their odor the carbolic-acid and chloride-of-lime solutions usually give way to the sublimate solution.

The rectum in those cases of intestinal infection should be

tightly plugged with cotton soaked in the sublimate or carbolic solution, and as soon as practicable the body should be placed in the coffin in which it is to be buried.

It is not advisable, even in the milder infective cases, to expose the remains in open caskets. The body should be buried or cremated; the results of the two processes of final disposal differing, as a rule, only in the time required for their accomplishment. If buried, the place selected should be so located as not to endanger neighboring drinking-water supplies.

QUARANTINE.

Quarantine may be defined as the segregation or isolation of such persons and objects as may be a menace to the health of the surrounding community, though the common usage of the term refers more to the enforced detention at ports of entry of persons, personal effects, and articles of merchandise coming by land or sea from localities in which dangerous epidemic diseases are in existence, to localities that are free from them.

Its object is to prevent the importation and dissemination of infectious maladies.

In its original meaning it implied the detention for forty days, this being regarded as the period necessary for the "self-consumption" of the morbific agents of acute epidemic diseases. In its modern usage, however, the word refers more to the process than to the time of its enforcement, the latter feature having been modified to meet the exigencies of particular cases; that is to say, there is no longer a fixed period of detention for all cases, but the length of this period varies according to the period of incubation of the particular disease against the importation of which the precaution is being taken.

In England there is a tendency to eliminate entirely the

enforced detention, the authorities preferring to rely more upon the prompt notification of outbreaks of contagious disease and upon measures that aim to place their ports of entry in such sanitary condition that epidemic diseases cannot gain a foothold, than upon the systems of quarantine as usually enforced.

Because of the serious embarrassment to commercial intercourse that the older methods of quarantine entailed, and because of the demonstrated inadequacy to close all channels of intercourse completely by such methods, numerous congresses of experts have convened for the purpose of formulating a more expeditious and trustworthy system for the management of suspicious and dangerous matters arriving from infected districts. Though no uniform plan has been adopted as a result of these debates, still it is evident that the tendency, briefly stated, is to depart very widely from the practices of former years and to rely more upon the prompt enforcement of active, trustworthy, sanitary measures than upon the uncertain element of detention.

Briefly summarized, such measures comprise:

Strict sanitary supervision of all ports of entry; the boarding and inspection of all vessels arriving from foreign ports, and in special cases of *all* vessels, from domestic as well as foreign ports. This latter is enforced when epidemic diseases existing in one part of a country are liable to be conveyed to another by means of maritime commerce.

The disinfection, fumigation, and cleansing of all ships found upon inspection to be possible causes of infection.

The removal from the ships to the hospital of the station of all passengers and crew found to be infected; also the removal to pavilions of observation of all other individuals from the ship and their detention for a period of time necessary to determine whether they are themselves infected or not.

The registration of all incoming persons, including the statement as to whence they come and whither they are going, and the compulsory notification of the authorities of any form of contagious disease that may appear among such persons either *en route* to or after reaching their destination.

The careful disinfection of the clothing and other personal effects of the passengers and crews from infected ships.

The removal and disinfection of the cargo or ballast from suspected ships or from ships coming from infected ports and believed to be infected.

The regular notification of the chief of the national or state quarantine service, by the quarantine officer in charge, of all pertaining to the ship under consideration, with a full description of the steps taken to render her free from danger.

The giving of free pratique to the ship, as soon as circumstances will permit, after she has been subjected to the methods of cleansing and disinfection deemed proper by the quarantine authorities.

To carry out this work properly it is necessary that the quarantine station be under the management of a staff of trained officers who are fully impressed with the importance of their work.

They should have at their disposal a corps of assistants who have been thoroughly instructed in the duties that they are to perform.

The station should be located at a place of safe anchorage, convenient to the channel of traffic, but sufficiently removed from populous centers and from the line of travel to prevent its being a source of danger to the surrounding community and to non-infected vessels and to their crews.

The station should be provided with the necessary boats, launches, or tugs for boarding in all weathers.

It should be provided with a steam-disinfecting plant of approved pattern for the disinfection of articles of clothing and of merchandise that may be brought on shore; with tanks for holding disinfecting solutions that are to be used on shore; with facilities for the bathing and personal disinfection of all suspected passengers and crews from infected vessels; with a detention-pavilion for the observation of persons from infected ships who are themselves at the time of quarantine not actually sick of the disease against which the ship is being quarantined; with properly equipped hospitals or pavilions for the treatment of all cases of contagious disease.

The general sanitary condition of the station as regards water-supply, food-supply, and drainage, heating and ventilation of barracks, etc., should be of the best.

All officers and assistants should have been vaccinated against small-pox, and for stations having frequently to do with yellow fever, it is advisable to select the staff from among individuals who have already had the disease.

There should be a rigid isolation of the hospital and detention-pavilions and their nurses and attendants from other buildings and persons of the station.

For the expeditious disinfection of ships' holds and cabins the station should be provided with a steam-vessel fully equipped with provisions for generating the fumigating gases in large quantities, for the liberation of hot water or steam under pressure, and with pumps for the forcible ejection of of disinfectants to be used in cleansing and disinfecting the ship.

There should be a crematory for the disposal by fire of all useless articles that may harbor infection.

In addition to maritime quarantine, to which the above particularly refers, we hear of other kinds of quarantine, though they differ from one another only in their application to different channels through which infection may be imported or spread, the object throughout being the same. Thus, for example, we hear of "railroad quarantine," meaning the sanitary supervision of persons and articles of merchandise arriving by rail from infected localities. In its mode of application it is essentially the same as maritime quarantine; of "house quarantine," meaning the prevention of inhabitants of infected houses from mingling with the general public, as well as the prevention of outside persons from visiting such houses unless duly authorized; of the "sanitary cordon," sometimes known popularly as "shot-gun" quarantine, meaning a system of isolation, sometimes unauthorized, that is conducted by surrounding infected districts with a cordon of armed patrols who are instructed to prevent, by force if necessary, all communication between the suspicious focus and the surrounding country.

In addition, we hear of systems of quarantine against certain specific diseases, as "yellow-fever quarantine," "cholera quarantine," "diphtheria quarantine," indicating at once the particular measures that are in force to check the spread of this or that disease.

While maritime quarantine is of necessity an elaborate process, as carried out at our great ports of entry, it is far more easy to conduct it consistently and with advantage to the public health than is inland quarantine. In the latter event the channels of intercourse are so numerous that their complete obstruction is a matter of practical impossibility. It is here that the importance of an adequate system of notification of contagious diseases is seen, for it is only by this means that outbreaks within our borders, originating through importation, can be early recognized, and receive the sanitary supervision that their gravity demands.

Quarantine was originally established to guard against the spread of the plague, but as time went on it was employed against additional contagious diseases, one after another, until at the present time it may be practised against practically all communicable diseases, though cholera, typhus fever, yellow fever, small-pox, and leprosy are the maladies against which it is conspicuously employed. It is, however, the opinion of those versed in the subject that all immigrants suffering from such diseases as the acute exanthemata, dysentery, glanders, beriberi, epidemic influenza, and in fact all communicable diseases, should be detained for a time necessary to place them beyond the point of danger to those with whom they may come in contact.

NOTE.—For details relating to the practice of quarantine in the United States, see the excellent publications of the Marine Hospital Service, notably:

"Quarantine Laws and Regulations of the United States," Treasury Department, Document No. 1677, Marine Hospital Service.

"A Precis of Quarantine Practice at National Quarantine Stations," prepared by Passed Assist. Surgeon H. D. Geddings: *Reports of U. S. Marine Hospital Service*, 1896, pp. 479–523.

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